This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

QE
328
.A3
1900
pt.2

B 1,372,426

QE
328
.A3
1900
pt.2

SURVEY DEPARTMENT, PUBLIC WORKS MINISTRY,
EGYPT.

GEOLOGICAL SURVEY REPORT, 1900.

PART II.

THE CRETACEOUS REGION OF ABU ROASH

NEAR THE PYRAMIDS OF GIZA

BY

HUGH J. L. BEADNELL, F.G.S., F.R.G.S.

CAIRO:
NATIONAL PRINTING DEPARTMENT
1902.

QE
328
.A3
1900
pt. 2

CONTENTS.

PAGE.
I.—INTRODUCTION 7

II.—TOPOGRAPHY 9

III.—GEOLOGY :
(*a*) Relation of the Cretaceous and Tertiary... 13
(*b*) Cretaceous Succession in the District 17
(*c*) Tertiary Deposits... 33
(*d*) Folds and Faults... 38
(*e*) Weathering 44

IV.—LIST AND EXPLANATION OF ILLUSTRATIONS. 46

143778

ILLUSTRATIONS.

For explanation see pp. 46–48.

PAGE.
PLATE I.—Sketch-map to show position of Cretaceous massif of Abu Roash with reference to Cairo and the Nile Valley... ... 9
„ II.—Geological map of the Cretaceous Region of Abu Roash near the Pyramids of Giza... ... ... In pocket.
„ III.—Jebel el Midauwara 10
„ IV.—North-east end of Jeran el Ful hills 15
„ V.—Jebel el Haggaf... 20
„ VI.—Part of the Dome of El Hassana 24
„ VII.—Unconformable Junction of Eocene and Cretaceous, (with intervening pebble-bed). Cliff on west of Sidr el Khamis. 28
„ VIII.—Junction of Eocene and Cretaceous in south-west corner of Sidr el Khamis 33
„ IX.—Crystalline Limestones of Jeran el Ful (showing erosion by wind-borne sand)... 34
„ X.—Bank of *Biradiolites cornu-pastoris* d'Orb. Turonian of Dome of El Hassana 37
SECTION I.—Escarpment west of Pyramids of Giza 14
„ II.—Escarpment west of Pyramids of Giza... 15
„ III.—Across Sidr el Khamis 16
„ IV.—From Abu Roash to Sidr el Khamis 22
„ V.—From Jeran el Ful to Jebel el Ghigiga 27
„ VI.—Across Jeran el Ful 30
„ VII.—Across Jebel el Haggaf 32
„ VIII.—Through Gaa escarpment... 39
PLATE XI.—Fragments of cherty and crystalline limestone shaped by wind-borne sand 43
„ XII.—Dreikanter and vermicular surface produced in crystalline limestone by wind-borne sand 45
„ XIII.—Curiously-shaped fragment of cherty crystalline limestone. 48

I.—INTRODUCTION.

The discovery of the Cretaceous region of Abu Roash, near the Pyramids of Giza, has usually been credited to Dr. Schweinfurth, but Mr. René Fourtau[1] has quite recently brought to notice the fact that the original discoverer was the French naval officer Lefebvre, who visited Egypt in 1835, and some time later announced the existence of the Abu Roash massif in a letter to the Société géologique de France.[2] Its existence, however, appears to have been so entirely forgotten, that Schweinfurth's rediscovery[3] of these Cretaceous beds in 1884 caused no little surprise.

Prof. Charles Mayer Eymar visited the district in 1886 and briefly refers to it in a paper[4] published shortly afterwards.

In February, 1887, Profs. W. J. Walther and G. Schweinfurth visited the region together, and the former afterwards published a paper,[5] giving the results of their combined labours.

Finally, Fourtau, in 1899, gave a brief account of the district in the paper already referred to, and the same author, in a work still more recently published,[6] on the echinids of Egypt, has briefly described some of the most fossiliferous beds.

Notwithstanding these somewhat numerous references the district was still imperfectly known, both geographically and geologically, and the present paper is therefore the first attempt to give an adequate description of the whole area; the accompanying map,[7] although by no means complete, or as accurate as could be desired, is sufficiently detailed for present purposes.[8]

---

[1] *Les environs des Pyramides de Ghizeh*, Bull. Soc. Khéd. de Géogr., Cairo, 1899, p. 191.

[2] Bull. Soc. Géol. de France, 1re sér., t. X., 1839, p. 144.

[3] *Uber die Kreide region bei den Pyramiden von Gizeh.* Peterm. Mitt., 35 band. 1889.

[4] *Zur Geologie Egyptens*, Vierteljahrs. Naturf. Ges. Zürich, 1886, pp. 241–67.

[5] *L'Apparition de la Craie aux environs des Pyramides*, Bull. L'Inst. Egyptien, Deuxième ser. N° 8, 1887, pp. 3–13.

[6] *Notes sur les Échinides Fossiles de l'Égypte*, Le Caire, 1900, pp. 9–17.

[7] Plate II.

[8] Unfortunately, the determinations of the fossils collected from Abu Roash have not yet been completed at the British Museum, and thus the present description cannot be as comprehensive as it might have been. I hope, however, to supplement the present communication at a future date.

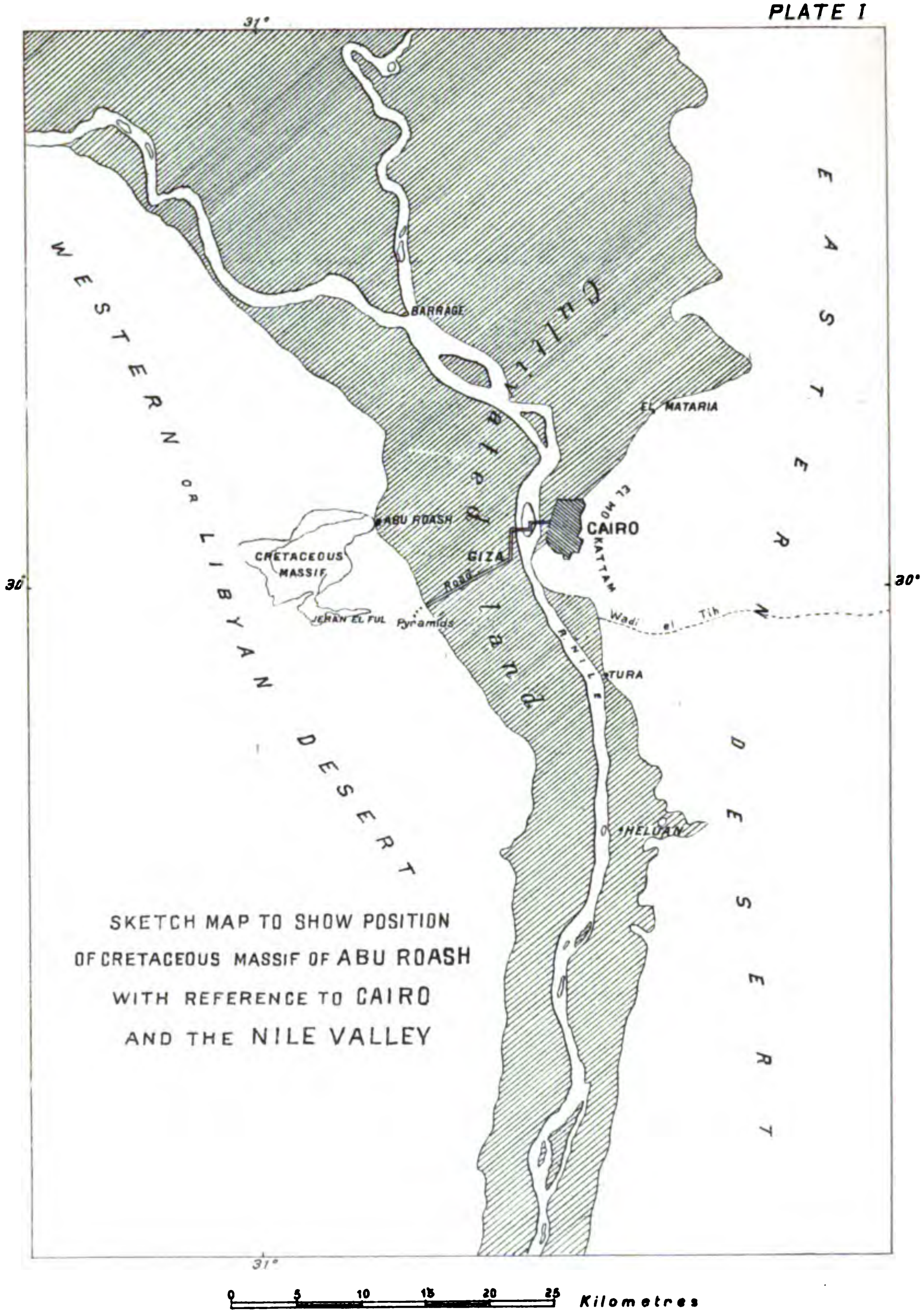
My survey of the district was commenced in June, 1896, during which month I made a general examination of the whole area and my colleague, Mr. G. Vuta, mapped it with the plane-table. This three weeks' work in fact constitutes the basis of the present map and report. With the exception of an occasional day's work when opportunity afforded, nothing more was done until the spring of 1900 when I camped out there for a fortnight and worked round the entire boundary, completing the geology and topography, and re-surveying a considerable portion of the area which proved inaccurate, owing to the hurry of the original work. During the summer of 1900 occasional visits from Cairo have enabled me to map in the faults of the Gaa massif and work out the succession, etc., as far as possible under such circumstances.

There yet remains, however, a considerable amount of detailed work to be done, especially among the faults and folds near the village of Abu Roash; but to show the positions of these correctly and the exact outcrops of the various divisions, a large-scale and very accurate map is indispensable.

H. J. L. Beadnell.

August, 1900

PLATE I



SKETCH MAP TO SHOW POSITION OF CRETACEOUS MASSIF OF ABU ROASH WITH REFERENCE TO CAIRO AND THE NILE VALLEY

II.—TOPOGRAPHY.

The Cretaceous area in question lies near the edge of the Libyan Desert, abutting in fact on the Nile Valley cultivation at the village of Abu Roash, 8 kilometres N.N.W. of the Pyramids of Giza, and 15 kilometres due west of Cairo (Plate I).

Although described by Walther[1] and Schweinfurth[2] as forming a regular rhomb, the Cretaceous region is in reality of very irregular shape. Omitting the southern and partly detached portion of Jeran el Ful, the remainder, including the massifs of Gaa and Ghigiga, and Jebel el Haggaf (Hakf), with the depression of Sidr el Khamis and part of the Wadi el Qurn, forms a roughly triangular area, the apex of which touches the village of Abu Roash. The centre line, or perpendicular, of this triangle stretches from the village into the desert in a W.S.W. direction for 10 kilometres. The Jeran el Ful district joins the main triangular area near the south-western extremity.

The approximate area of the whole Cretaceous exposure is 48 square kilometres.

A brief topographical description of each district follows.

Plateau of the Pyramids of Giza.—This low limestone plateau, supporting the Pyramids of Giza, occupies the south-east portion of the map (Plate II). It ends abruptly on the north side with a conspicuous east and west escarpment facing the low-lying area of Wadi Talun. This escarpment, often made up of two or more steps, continues westward for several kilometres, becoming, however, much less conspicuous, until in the neighbourhood of Jeran el Ful it has practically died out.

Jeran el Ful.[3]—A small range of hills 5 kilometres west of the Pyramids of Giza.[4] Owing to peculiar weathering into a great number of dark-coloured conical peaks, this group of hillocks presents a striking appearance, especially if viewed from a distance, when the contrast between it and the surrounding undulating, sandy, pebble-covered, desert is most marked. Its name is derived from the resemblance of the conical hillocks to the heaps of beans on a threshing-floor.

---

[1] *Loc. cit.* p. 5.

[2] *Loc. cit.* p. 1.

[3] Gour el Hamir of Walther; Ghéran el Foul of Fourtau.

[4] Distances thus referred to are measured from the centre pyramid, that of Chephren.

Wadi Talun.[1]—The whole of the low-lying country between the large triangular Cretaceous area already mentioned (Gaa, Ghigiga, Jebel el Haggaf) and the northern escarpment of the Pyramid plateau is known to most Arabs as the Wadi Talun. It includes numbers of different drainage lines, notably those on either side of Jeran el Ful. Although a rather vague term, it will be useful in referring to the low, undulating, pebbly desert between the Pyramids and the Abu Roash hills.

Passing now to the large triangular Cretaceous area we find this divisible topographically into an east and a west division, *i.e.* Gaa and Ghigiga.

Gaa.—The name Gaa seems to be used by the Arabs to embrace the entire hill-range between the village of Abu Roash and Jebel el Ghigiga, a distance of about 4 kilometres. In the centre of this group of hills is the plateau of Gaa, perhaps the most conspicuous summit in the entire district. Its height above the cultivated land of the valley is about 140 metres. On this plateau are the remains of one or more pyramids, usually attributed to the fourth dynasty.

Immediately to the east the plateau is bounded by a sheer escarpment, about 100 metres high, facing the Nile Valley. This escarpment is the most conspicuous feature of the whole district, and even from Cairo, on a clear day, presents a striking appearance, quite unlike the usual Eocene cliffs.

Below this escarpment is a roughly circular basin or amphitheatre draining out into the valley by a narrow gully on the east side. Owing to the geological structure of the ground this amphitheatre is partly bounded by a succession of step-like terraces, which run in a regular curved manner all round the western side of the basin below the Gaa escarpment. To this peculiarity the locality owes its name of Jebel el Midauwara. The basin is bounded by other hills of irregular shape on the south and east sides, each of which has its own particular name among the Arabs.

The Gaa plateau is reached by an ancient though well-made inclined embankment or road from the north-east side.

---

[1] Spoken of as the Derb and Darb-el-Fayum by Walther and Fourtau. This term, meaning "the Fayum road," should, however, be restricted to an actual track and not applied generally to a large tract of country.

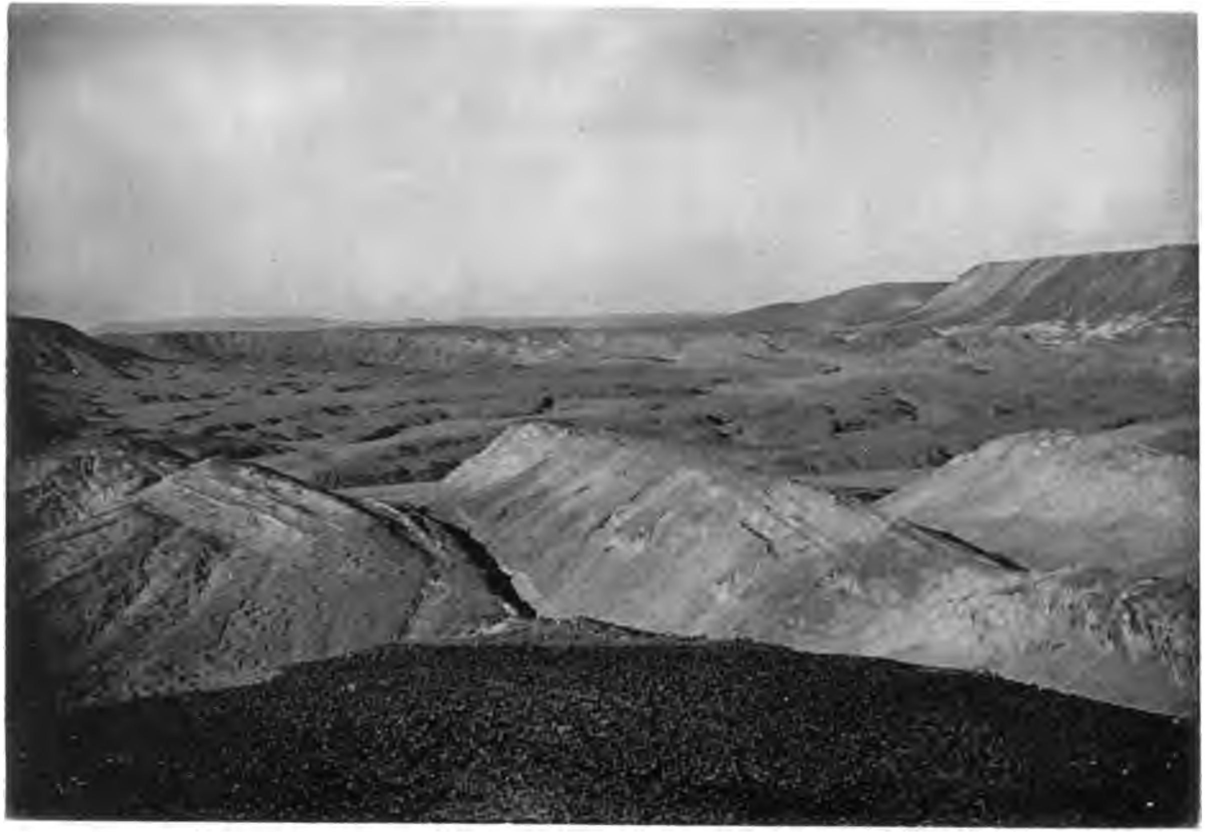


Plate III. Jebel el Midauwara.

To the west and north the plateau slopes down and is bounded by parallel curved ridges and steep gullies, the shape and disposition of which are always intimately connected with the geology. One kilometre W.S.W. of the Gaa pyramids, in the low area between the higher masses of Gaa and Ghigiga, is situated a conspicuous round dome-shaped hill, surrounded by several successive concentric gullies and ridges, which are complete for nearly two-thirds of the circle. This dome, included under the term Gaa by the Arabs, is so important and peculiar that I shall refer to it hereafter as the "dome of El Hassana." The little wadi, which forms a pass through the hill-range at this point, is known as the Derb el Hassana.

Jebel el Ghigiga; Jebel el Haggaf (*Hakf*).—The great hill-mass to the west of Gaa, extending to the depression of Sidr el Khamis, known as Jebel el Ghigiga, attains the maximum height in the whole district, *i.e.*, about 175 metres above the Nile Valley cultivation. On the south side it is separated by a synclinal hollow, the continuation of the above-mentioned depression, from Jebel el Haggaf (also pronounced Hakf) a long ridge with a well-marked escarpment facing Jeran el Ful, but separated from it by the low undulating pebbly desert of Wadi Talun.

Sidr el Khamis.[1]—A well-marked basin lying on the west and south sides of Jebel el Ghigiga, and enclosed on the west by an irregular chalk cliff. It has no drainage outlet, the mouth of the little gully of the south side (cutting through Jebel el Haggaf), which appears at first sight to form a drainage outlet, being considerably higher than the bottom of the depression.

Wadi el Qurn.—Applied to the low-lying tract of country bounding the Gaa–Ghigiga range on the north side. A part of the wadi is cut out in Cretaceous rocks. The name is derived from Jebel el Qurn,[2] a hill a few kilometres north-west of Jebel el Ghigiga.

El Qulaya.[3]—A prominent conical hill, isolated and black-coloured, in the Wadi el Qurn, just beyond the northern slopes of Jebel el Ghigiga, and 3½ kilometres west of the Gaa pyramids.

---

[1] "Berak el Gazal" of Fourtau. This term is a misnomer, and not generally recognized by the majority of the Bedawin.

[2] From the Arabic for a "horn." The wadi is marked "El Ouady Sehl" on Fourtau's sketch-map.

[3] El Goléa of Walther. Fourtau (*loc. cit.*, "Echinides Fossiles, etc.," p. 12) says: "El Golea est aussi une localité indiquée par Walther et inconnue des bédouins." As a matter of fact, however, the hill in question is well known to the Arabs, although Walther's spelling of the name is incorrect. As everybody who has travelled much in the Western Desert knows, different tribes and even different families often have different names for the same place, and most Arabs, rather than confess to ignorance as to the name of a place or hill, will, when questioned, at once use their imagination and supply a name. With some trouble, however, it will usually be found that the Arabs of any particular district have definite and well-recognized names for all the principal places.

The chief localities of the district have now been briefly mentioned and further topographical explanation must be left to the following geological account. The topography, as also the scenery, is so intimately connected with the geological structure that a description of the former is impossible without reference to the latter.

III.—GEOLOGY.

(a) *Relation of the Cretaceous and Tertiary Deposits.*—(b) *Cretaceous Succession in the District.*—(c) *Tertiary Deposits.*—(d) *Folds and Faults.*—(e) *Weathering.*

(*a*) Relation of the Cretaceous and Tertiary Strata.

The occurrence of such an isolated exposure of Cretaceous rocks in the midst of the Eocene plateau has occasioned no little surprise to the different observers who have visited Abu Roash. This was natural in that Zittel, who had traversed a large part of the Libyan Desert, including most of the oases, during the progress of the Rohlfs Expedition, had stated,[1] as one of his most important results, the existence of a perfectly gradual palæontological and lithological passage from the uppermost Cretaceous into the oldest Tertiary beds. This supposed complete marine development of the Cretaceous and Eocene and absence of any break between the two formations, was naturally regarded as of the highest importance, especially considering the more or less abrupt separation between the Mesozoic and Cainozoic in Western Europe.

This stated uniformity of stratification in the Libyan Desert being at that time an accepted fact, Walther's surprise, as expressed in his work, is quite intelligible. He says:[2]—"Je reconnus sans peine que par des dislocations bizarres, la craie avait été soulevée et mise à jour. Après que les explorations du Professeur Zittel eurent constaté l'uniformité du plateau lybique par rapport à sa stratification, l'existence d'une configuration appartenant au système de voûtes rompues et démantelées dans ces parages paraissait tout à fait étonnante."

Walther and Schweinfurth thus came to the erroneous conclusion[3] that the Cretaceous was brought into its position in the Eocene by faulting, a conclusion probably largely suggested by the well-marked faults which occur within the Cretaceous complex. As will be shown, however, these faults are pre-Eocene, not post-Eocene.

---

[1] Palæontographica (*Beitr. z. Geol. u. Palæont. d. Libys. Wüste* 1883, pp. 90 and 94).

[2] *Loc. cit.*, *L'Apparition de la Craie*, etc., p. 4.

[3] *Loc. cit.* p. 1, "On all four sides the Cretaceous is brought into contact with the upper Eocene formation of the Mokattam by straight fault lines........"

The former says;[1]—"L'existence de la formation crétacée dans ces parages est d'autant plus étonnante que la craie touche immédiatement aux couches de l'éocène supérieur (Parisien supérieur) à *Carolia*, *Plicatula polymorpha*, *Solen unicostatus*, *Agassizia*, et autres fossiles typiques des couches brunâtres du Mokattam. Nulle trace de l'étage nummulitique inférieur. On ne saurait guère supposer que dans une localité si voisine du Mokattam l'éocène inférieur n'eût trouvé son développement, et que l'éocène supérieur fût superposé presque sur tout le pourtour de son extension immédiatement et en discordance à une couche crétacée. Il ne nous reste donc que la supposition que toute cette région soit entourée de failles de dislocation."

In the map[2] of the district accompanying Walther's paper, the position of these chimerical faults between the Eocene and Cretaceous is shown over a large extent of the boundary, and the junction of those two formations is always shown as a fault in the various published sections.

As I have already pointed out[3] these faults do not exist, the junction of the Cretaceous and Eocene being one of unconformity and overlap. The evidence for this will now be given in detail.

(1) *The junction of the Cretaceous and the Eocene at Jeran el Ful, and near the Pyramids of Giza.*—As already mentioned the Eocene plateau, on which the pyramids are built, has a well-marked, nearly east and west, escarpment facing the north. Walther draws a fault along the base of this cliff, though the evidence on which he relies is not apparent. Immediately below the cliff and separating it from the undulating desert of loose pebbles and sand to the north, is a small valley or drainage line which has its origin on the north side of Jeran el Ful, about 5 kilometres to the west. The floor of this valley is covered with sand and loose down-wash. Although no Cretaceous beds are visible either in this valley or on the undulating ridges to the north, it is not unlikely, in consideration of what occurs 2–3 kilometres further west, that they exist, hidden by the sand and gravel, and pass unconformably under the *Nummulites gizehensis* beds (Lower Mokattam).

---

[1] *Loc. cit.* p. 10.

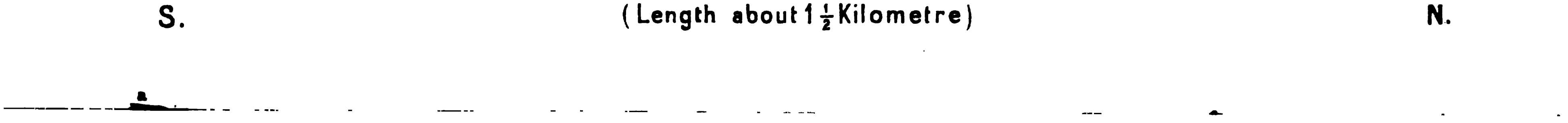
[2] "Plan des principales failles du terrain crétacé à l'ouest des grandes pyramides, dressé d'après les relèvements de M. Schweinfurth," par J. Walther.

[3] *Geological Magazine*, No. 427, Jan. 1900. "Correspondence" (H. J. L. Beadnell), pp. 47-48. Also, "Recent Geological Discoveries in the Nile Valley and Libyan Desert," London, 1900. (*Découvertes Géologiques Récentes dans la Vallée du Nil et le Désert Libyen*, Compte rendu, VIIIe Congrès Géologique international, 1900; Paris, 1901).

SECTION I

DIAGRAMMATIC SECTION THROUGH ESCARPMENT 3 KILOMETRES WEST OF THE GREAT PYRAMIDS

(Length about 1 $\frac{1}{2}$ Kilometre)



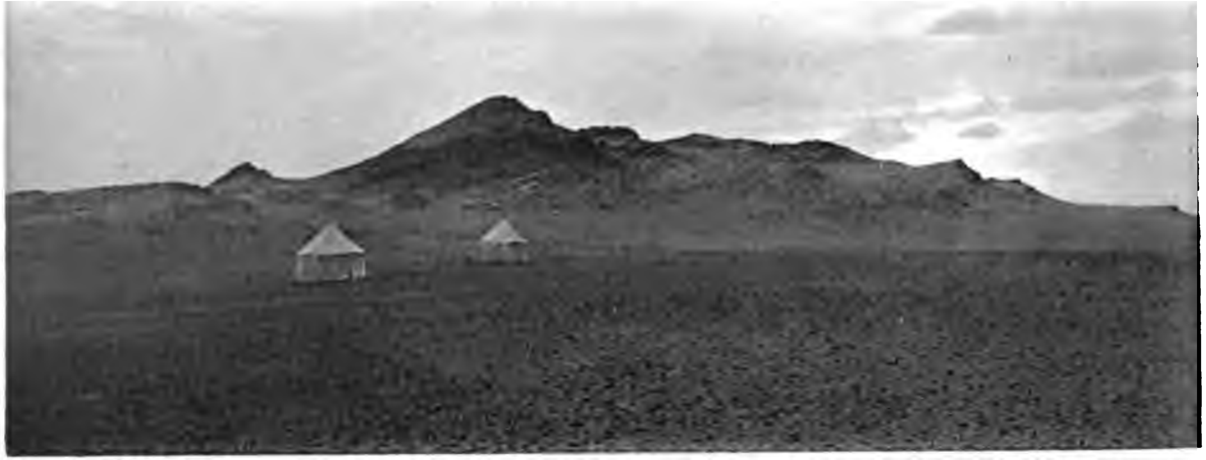


PLATE IV. NORTH-EAST END OF JERAN EL FUL HILLS.

Half-way between the Pyramids and Jeran el Ful, the same Eocene beds, that form the escarpment at the former place, occur, bent into a gentle synclinal fold, while the lower beds, the *Nummulites gizehensis* limestones, hard and semi-crystalline in character, again form a well-marked escarpment, about a kilometre in length, facing north. In this case, however, a soft chalk containing *Ostrea* sp. etc., is visible, outcropping here and there in the sandy pebble-covered valley below. It is almost certain that this chalk is a Cretaceous bed, as it can be traced almost uninterruptedly into similar soft beds of the well-marked Jeran el Ful series. There is little doubt that this chalk passes under the Lower Mokattam beds of the escarpment, but the junction is again invisible, the lower portion of the cliff being obscured with talus and accumulations of blown sand.

Sections I and II are drawn across this locality.

At Jeran el Ful we are left in no doubt about the character of the Eocene–Cretaceous junction. On the south side of the range the valley is cut out in the upper soft beds of the Cretaceous; here we find soft marls and marly limestones, with occasional crystalline bands (only a few metres thick), dipping to the south at an angle of from 15°–18°, overlain by a series of Upper Mokattam beds, either horizontal or with only a very low dip in the same direction. The base of the Eocene at the actual junction is a limestone-grit with numerous small *Nummulites*, often containing rounded pebbles of hard, crystalline, Cretaceous limestones—exactly similar to those forming the adjoining range of hillocks—and occasional derived oysters similar to those which occur in the underlying beds. The beds become less gritty as we pass upwards, hard-yellowish brown shelly limestones of the common Upper Mokattam type soon being in evidence. The detailed section (No. VI) will best show the relations of the two series at Jeran el Ful.

Half a kilometre north-west of Jeran el Ful a small rounded hill, composed of Eocene beds with a slight westerly dip, occurs. The upper beds are shelly limestones; these become less pure below, passing into limestone-grits and finally into sandstone and coarse conglomerate at the base; the unconformable junction of the latter with hard, crystalline, Cretaceous limestone below is visible at one point, but usually obscured by sand and loose pebbles.

The very irregular trend of the junction of the Cretaceous and Eocene between Jeran el Ful and Sidr el Khamis can be seen by a glance at the map (Plate II), and I will therefore pass on to the latter locality.

Junction in Sidr el Khamis.—This depression, cut out in the soft marls and limestones at the top of the Cretaceous, is surrounded on the south and west sides by an irregular trending cliff of snow-white chalk, in which however the bedding places are usually clearly marked. The chalk dips as a general rule at about 8–10° westwards, but varies somewhat from point to point. It is throughout overlaid at the same general level by a series of Upper Mokattam beds full of typical fossils. These beds are either horizontal or have a low inclination; on the south side[1] of the depression they dip at about 3° to the south, while the underlying chalk dips about 8–10° to the west (Plate VIII); while on the west side both series dip westwards, but with a difference of inclination of about 8°.

Moreover, at several points along this cliff a bed of rolled pebbles is seen to intervene between the two series (Plate VII). The upper surface of the Cretaceous white chalk (dipping 8–10° west) is very irregular, and evidently underwent considerable erosion before the deposition of the overlying Eocene deposits. It is covered by a conglomerate (1½–1 metre thick) of rolled crystalline limestone pebbles, derived from the lower Cretaceous beds of Ghigiga, Jeran el Ful, etc., which are set in a calcareous base of smaller similar pebbles, together with limestone and siliceous sand grains. The base of this bed is strongly stained with brown iron oxides. The pebble bed is overlaid by an almost horizontal bed of yellowish-white shelly, limestone (2 metres), often passing into a typical limestone-grit at the base. This is followed by other limestone bands, the whole series above the pebble bed being of Upper Mokattam age, containing a numerous assemblage of typical fossils including the genera *Carolia*, *Ostrea*, *Conus*, etc.

Plate VIII is a photograph of the unconformity in the south-west corner of Sidr el Khamis. It was here that Walther's "Camp en 1887" was situated, but his map, as well as a section drawn through this point, shows a continuous bounding fault between the Cretaceous and Eocene!

Plate VII is a photograph showing the intervening pebble bed just described, and Section III is drawn through the same locality.

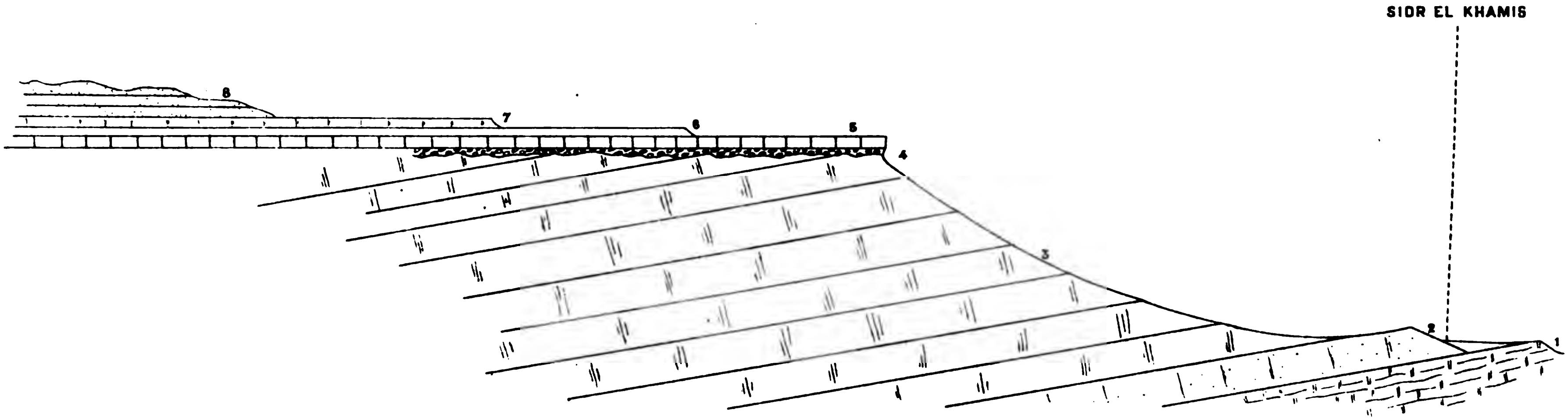
Junction of Cretaceous and Eocene along the north boundary.—An examination of the boundary along the north side only confirms the conclusions already formed. Throughout the whole length, over a

---

[1] This is close to Walther's "Camp in 1887." Schweinfurth, (*loc. cit.* p. 1) after stating that the Cretaceous is brought into contact on all four sides with the Eocene by faultlines, says of this locality: "This relationship is most sharply displayed in the acute angle of the rhomb which is directed towards the S.W. Here the upper Cretaceous strata are connected with (or adhere to) the horizontally deposited bed (AAA, 1 [*i.e.* Eocene]) in such a manner that the two formations constantly meet together along the line of the edge of the escarpment, quite independently of the stage to which the denudation of the beds have been advanced." This itself shows the unconformability and could not be produced if the junction was along a line of fault.

SECTION III

DIAGRAMMATIC SECTION ACROSS THE CRETACEOUS-EOCENE JUNCTION OF SIDR EL KHAMIS 12 KILOMETRES W.N.W. OF THE GREAT PYRAMIDS.



LOWER OLIGOCENE.		8	*Sandstones and grits.*
MIDDLE EOCENE	UPPER MOKATTAM	7	*Limestone with Ostrea, etc.*
		6	*Beds with Carolia placunoides.*
		5	*Limestone-grit and shelly limestone.*
		4	*Conglomerate of rolled Cretaceous pebbles.*
UPPER CRETACEOUS	DANIAN	3	*White Chalk.*
	SENONIAN	2	*Ammonite bed.*
		1	*Plicatula and Ostrea beds*

distance of over 10 kilometres, the Cretaceous, usually consisting of the upper beds (white chalk, etc.), is unconformably overlaid by Eocene shelly limestones or limestones-grits. The dips are invariably different in the two series, chiefly in amount, but at times also in direction. Moreover, the junction is very irregular, quite unlike one which could be explained by faulting. At some points a band of conglomerate immediately overlies the Cretaceous, notably at a point 5½ kilometres west of the village of Abu Roash.

At the north-east corner of the Cretaceous exposure, about 1½ kilometres W.N.W. of Abu Roash, the white chalk appears to have a dip of about 10° to the north. It is overlaid by a single bed of brown limestone-grit, evidently of Upper Mokattam age. The latter, curiously enough, has apparently at this point a somewhat steeper dip than the underlying Cretaceous; the directions of dip of the two series are also somewhat different. Walther, as usual, considers a fault to mark the junction, but it is quite clear that here as elsewhere the latter is one of unconformability. The Eocene is only exposed as a very narrow band, being almost immediately overlaid by later deposits which will be described further on.

With regard to the east, and last, side of the Cretaceous area, we may safely conclude that before the formation of the Nile Valley the junction with the Cretaceous was there, as elsewhere, unconformable. At the present time the Cretaceous hills, near the village of Abu Roash, abut immediately against the Nile Valley river alluvium. Walther inserts a bounding fault along this side, but in the absence of proof it is more natural to regard the escarpment as having been formed by marine action (as also the escarpment of the Pyramids plateau), when the sea stretched up here in Pliocene times.

(*b*) **Cretaceous Succession in the District.**

Schweinfurth,[1] in 1884, on first meeting with these Cretaceous beds near Abu Roash, regarded them as of Senonian age. The same author[2] afterwards showed that the oldest beds in the region (Schweinfurth's σ, 20 metres of brown sandstone) were Cenomanian, comparing them with the ammonite beds of the Eastern Desert (Wadis Regalah and Hawashia).

Blanckenhorn and Walther[3] appear to agree with Schweinfurth in regarding these lower beds as Cenomanian. The middle beds have unanimously been referred to the Turonian and the beds following are regarded by Blanckenhorn as Senonian.[1] Finally, the uppermost beds of all are, as I shall show, in all probability of Danian age.

---

[1] Walther, *loc. cit.* p. 3.

[2] "Petermann's Mitt.," 1889.

[3] In a publication only recently brought to my notice (*Sur le Crétacé du massif d'Abou-Roach* (*Egypte*), Comptes rendus, Acad. des Sciences, tome CXXXI, N° 16. Paris, 1900). Fourtau maintains that the lower beds are of Turonian age, and not Cenomanian as Schweinfurth, Walther and

The following summary, compiled by Blanckenhorn,[2] shows the succession recognized in the area until recently.

SENONIAN	CAMPANIAN	Limestone, sandstone, and chalky-limestone, with *Gryphæa vesicularis* (about 45 metres).
	SANTONIAN	Marl and limestone with *Hemiaster Fourneli*, *Ostrea Heinzi*, *O. Bourguignati*, *O. dichotoma*, *O. Costei*, *O. proboscidea*, *Plicatula Ferryi*, *Tissotia Tissoti* (20 metres).
TURONIAN		Limestone with *Phyllocœnia*, *Trochacteon Salomonis*, *Nerinea Requieniana*, *Biradiolites cornu-pastoris* (20–25 metres).
CENOMANIAN		Unfossiliferous limestone. Limestone with *Cyphosoma Abbatei*, *Hemiaster lusitanicus*,[3] *Sphaerulites Zitteli* and small Radiolites. Oyster beds. Brown Sandstone. (together about 100 metres.)

Owing to the highly disturbed nature of the beds, due to folding and faulting, it is a matter of no small difficulty working out the complete succession for the entire area. In few parts of the district is there a complete series from the lowest to the highest beds, so that the entire succession has to be compiled from a number of different localities. This has now been done, and I feel confident, after repeated checking, that while no beds have been omitted, neither have any been reckoned

---

Blanckenhorn consider. He records a bed containing *Callianassa Archiaci* Miln. Edw., *Serpula gordialis*, Schloth., *Arcopagia* aff. *elegans*, *Corbula* cf. *Goldfussi*, *Astarte* sp. n. aff. *subnumismalis*, Th. and Peron., a fauna with close affinities to that of the Turonian of Algeria and Tunis.

In the absence of definite information as to the locality where this fauna was collected I do not feel satisfied as to the position of the bed in the series, especially as the author's thicknesses differ widely from our estimates.

Part of the collection sent for determination to the British Museum was taken by Dr. Gregory to Melbourne; this part includes the echinids, the determination of which would probably settle the somewhat vexed question as to whether the lower beds should be regarded as Cenomanian or Turonian. No information, relating to these specimens has, however, yet been received.

Fourtau further points out that Blanckenhorn's *Hemiaster* cf. *lusitanicus* is in reality *Periaster roachensis* Gauth. Finally he gives his opinion that the beds with *Ostrea vesicularis* are Santonian rather than Campanian, and that no beds younger than Santonian exist at Abu Roash.

[1] See, however, Bullen Newton, Geolog. Mag. No. 418, April, 1899, p. 189.

[2] *Neues zur Geologie und Palæontologie Ægyptens*, Zeitschr. der Deutsch Geolog. Gesellschaft, Jan. 1900. Tabelle, facing p. 32.

[3] Corrected to *H. roachensis* in copy of paper kindly sent me by the author.

twice over. To any one acquainted with the ground this is a matter of some satisfaction, as along some lines certain groups of beds are repeated again and again by faults.

The chief divisions recognized in the field are as follows: —

On Map and Sections.	Beds.		Chief Fossils.	Thickness in Metres.
α	Danian.	White Chalk.	*Cœlosmilia laxa, Spondylus, Pecten, Exogyra cf. Langloisi, Gryphœa vesicularis, Rudistæ.*	100
β	Senonian.	Ostrea and Plicatula Beds.	Ammonites (*Tissotia Tissoti*). *Echinobrissus Waltheri.* *Plicatula Ferryi, Galeolaria filiformis.* Also throughout numerous large oysters; *O. Costei, dichotoma, Heinzi, Bourguignati, proboscidea, acutirostris.*	58
γ	Turonian.	Flinty Series.	*Phyllocœnia Toucasi.* Corals (small branched forms). *Amorphospongia tumescus.*	43
δ		Acteonella-Nerinea Limestone.	*Acteonella (Trochacteon) Salomonis.* *Nerinœa Requieniana.* *Millestroma Nicholsoni.* *Ceriopora* aff. *orbiculata.* *Biradiolites cornu-pastoris.*	35
ε		Hard, compact and often chalky, Limestones.	Poorly fossiliferous, but contain a similar assemblage to δ.	130
ζ	Cenomanian.	Rudistæ Beds. Alternating Shales. Marls and Limestones.	Radiolites. *Sphaerulites Zitteli.* *Periaster*[1] *roachensis.* *Cyphosoma Abbatei.*	40
η		Clays and Sandstones.	Poorly fossiliferous.	34
		Base.	Total thickness exposed...	440

Although this is more than double the thickness previously assigned to the Cretaceous of this district there is little doubt that the estimate cannot be greatly in error.

Each of these divisions will now be described separately, and further information can be obtained from the detailed Sections.

---

[1] *Hemiaster* according to Blanckenhorn.

CENOMANIAN.

η. Clays and Sandstones.

These are the oldest beds in the district and may be regarded as the top of the Nubian Sandstone. They are best exposed in the amphitheatre below Gaa escarpment, where they occupy the whole of the lowest ground, dipping at a slight angle of 1–2° west. In this locality they consist of alternating clays and marls, sands and sandstones, the former frequently gypsum-bearing and of a grey colour, the latter usually of a ferruginous brown. Some of the clays contain black carbonaceous bands with traces of plant remains, but the series is otherwise almost unfossiliferous. The same beds are also exposed along the southern flank of the hills facing, and north-west of, Kirdassa village, and also in the little gully adjoining the southern end of the village of Abu Roash, in the latter place being exposed owing to a small fault.

Again the same beds are exposed along the base of the southern escarpment of Jebel el Haggaf and at the base of the northern escarpment of Jeran el Ful (at the western end).

At Jebel el Haggaf[1] they are alternating brown sandstones, sands, sandy clays and sandy limestones, the latter frequently being rich in casts of small shells.

At Jeran el Ful a white sand alternating with dark brown sandy limestone forms the base, followed by saliferous clays and more sandy limestone, the latter sometimes containing calcite druses; the upper beds are sandstones.

The maximum thickness exposed is about 30 metres; but there is no hard and fast line between this and the series above.

ζ. Rudistae Beds.

An alternating series of shales, marls, and limestones, always found overlying the last-mentioned division in all the above localities.

---

[1] Walther apparently took these sandstones to be the equivalent of the dolomitic limestones of El Qulaya, which occur at the base of the White Chalk forming the uppermost Cretaceous beds. The limestones above he thought probably corresponded to the Alveolina beds of the Lower Eocene. The escarpment is, however, as seen in Section VII formed of η, ζ, ε, and δ. On p. 9-10 he writes. "Dans la dépression au pied de l'escarpement qui s'élève à huit kilomètres de distance à l'ouest des grandes Pyramides, le même grès (le grès......... qui se trouve à Goléa) apparait. C'est à la base de l'escarpement qui fait face à la petite chaîne de Gour-el-Hamir (Jeran el Ful), et qui compte cinquante mètres de calcaire blanc superposé. Je n'y pouvais guère reconnaître de fossiles, et il est fort probable que ces couches correspondent aux strates à alvéolines que M. Zittel a observés dans les oasis du désert Libyque et qui forment la transition aux couches éocènes du Londinien." Walther appends a note saying that according to Schweinfurth the sandstone was the equivalent of that mentioned earlier (*i.e.*, of Gaa amphitheatre?) and the limestones above of the Radiolite and Acteonella beds. Schweinfurth was perfectly correct.

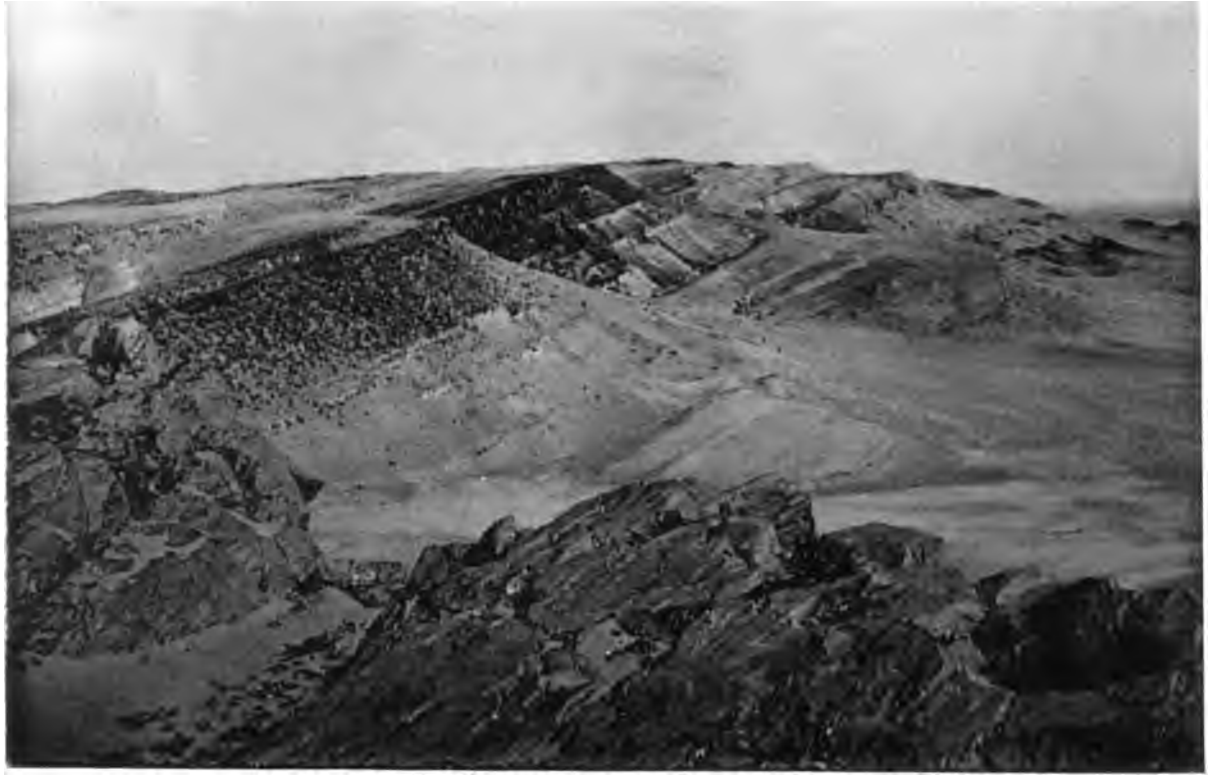


PLATE V. JEBEL EL HAGGAF.

The Rudistæ beds were first studied by Schweinfurth, at the base of the escarpment of Gaa (Plate III), where they form the concentric ridges of Jebel el Midauwara, and I cannot do better than give that observer's own section as quoted by Blanckenhorn.[1]

Base.

ρ Marls and marly sandstones with two lenticular bands containing a smooth, and a small ribbed, oyster.
π Marl and limestone with gypsum. Small Rudistæ.
ο Calcareous bed with *Hemiaster roachensis*, Lor. *Cyphosoma Abbatei*[2] Gauth, *Echinobrissus* sp.[3]
ξ White chalk alternating with gypseous clay.
ν Limestone with flints and *Sphærulites Schweinfurthi* Zitt.

This series is also well seen immediately above the brown sandstones at the base of Jebel el Haggaf; the following are the chief divisions:—

Base.	Metres.
Clays and marls...	5
Limestones with *Cyphosoma Abbatei*	8
Limestones with *Ostrea* bands	16
Clays and marly limestones with salt and gypsum	7
Limestones with *Sphærulites*	4
Marly clays	1½

For fuller details see page 32.

At Jeran el Ful the beds of series η pass up into clays with thin bands of sandstone crowded with small lamellibranch casts. Above come crystalline limestones in which fossils, except for a band with numerous small Radiolites near the base, are obliterated.

The average thickness of the series ζ may be taken as 40 metres.

TURONIAN.

The exact line of demarcation between the Cenomanian and Turonian is somewhat doubtful. Blanckenhorn[4] includes the great thickness of almost unfossiliferous limestones (of the Gaa escarpment, *i.e.* ε of the writer) with the Cenomanian beds below; but the occurrence of bands containing *Acteonella*, *Nerinea*, etc., in this series at Jeran el

---

[1] *Loc. cit.* p. 34-35.

[2] *Pseudodiadema* of Walther, but *Cyphosoma Abbatei* Gauth according to Fourtau. See latter's *Échinides fossiles de l'Égypte*, pp. 13 and 21.

It is unfortunate that specimens of these and others collected by the writer, many several years ago, have not yet been determined, as there exists a considerable amount of confusion in the classification of the fossils from this district.

[3] Personally the writer has not met with this genus in these beds. Great caution must be used in collecting, as in some areas the series β is brought into conjunction with η and ζ by faults, and fossils are then liable to become mixed on the surface.

[4] *Loc. cit.* Table facing p. 32.

Ful, makes it preferable to include them with the Turonian beds,[1] containing similar fossils, above.

ε. HARD, COMPACT, AND OFTEN CHALKY, LIMESTONES.

This series, in addition to the localities already mentioned—Gaa escarpment, Jebel el Haggaf and Jeran el Ful, where it always follows on above the last-mentioned series ζ—can be studied at a number of other points, being repeated again and again by numerous faults. The chief of these are the different ridges of faulted inclined rocks near Abu Roash village, at different points along the northern flanks of Gaa, at the dome of El Hassana and again half a kilometre further west on the eastern end of Jebel el Ghigiga, and finally forming the summit and flanks of that massif south and south-west of El Qulaya.

The series, some 130 metres thick, is the least fossiliferous of the entire Cretaceous succession.

At Gaa it forms the whole of the escarpment from above the series ζ to the top, and consists for the most part of hard compact chalk and chalky limestone, with occasional harder siliceous bands. Flints occur chiefly near the base. About half-way up a band containing gastropods and *Callianassa* (?) occurs, but beyond this the series is practically unfossiliferous. Under the pyramids of Gaa it passes into the Acteonella-Nerinea beds.

At the dome of El Hassana it forms the central core bent into a most remarkable fold (Plate VI.) The beds are here identical with those of Gaa escarpment. (Section IV.)

In Jebel el Ghigiga the beds of this series have been rendered crystalline and the fossils more or less obliterated, but in this locality they can be seen to contain large masses of *Millestroma*[2] (*M. Nicholsoni* Greg.?) in their upper layers, which still further unites them with the undoubted Turonian above.

At Jeran el Ful, the series ε is seen as a thick mass of highly crystalline limestones dipping at a constant angle of 20° to the south (Plate IX). Some of the beds form an intensely hard and crystalline marble, which may be of some economic value.

The beds have a peculiar habit of weathering into numerous parallel rows of black or dark conical hillocks, separated by flat smooth pavement-like valleys. The action of blown sand is beautifully seen on the surface of these rocks.[3] With the exception of occasional bands containing

---

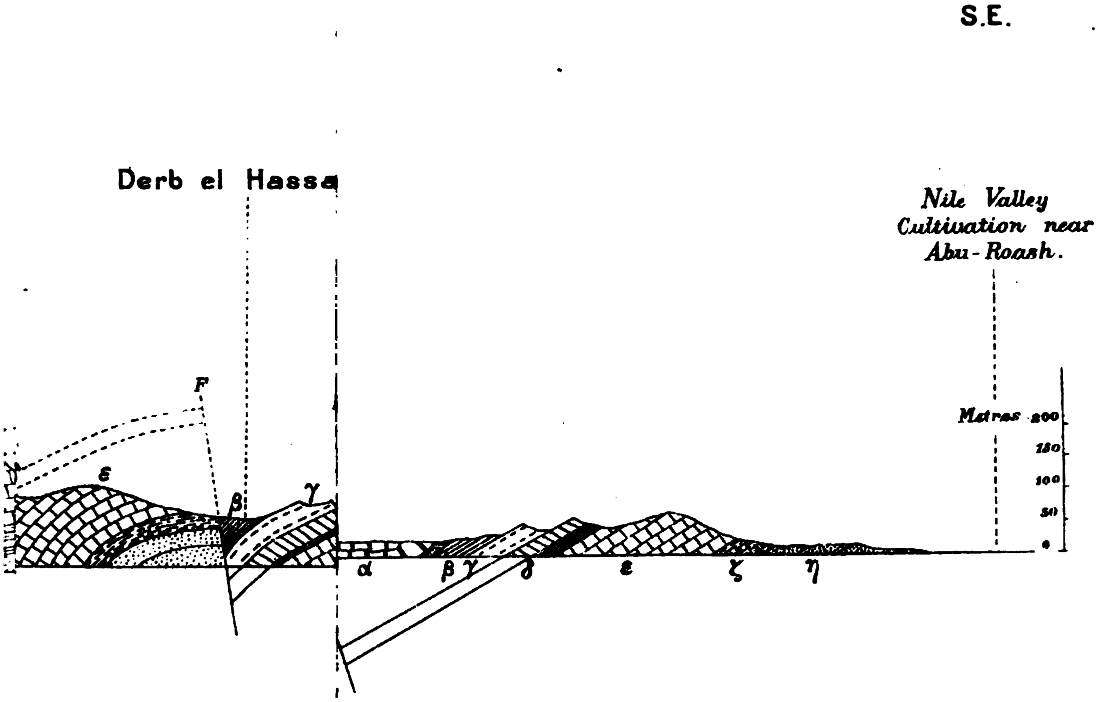
[1] Walther apparently considered both these and the underlying beds as Senonian. See Fourtau, *loc. cit.* pp. 16-17.

[2] See foot-note p. 23.

[3] See Fig. 3, in *Découvertes géologiques récentes*, etc., by the writer.

WEST OF SIDR

SECTION IV.



FF = Faults.

numerous casts of *Acteonella* and *Nerinea* and less frequent bands of *Millestroma*, the series is here, as elsewhere, almost unfossiliferous.

At Jebel el Haggaf also the series is highly crystalline, and contains bands of hard crystalline dolomite; some of the lower beds, notably a crystalline dolomite (containing 40% magnesium carbonate) near the crown of the southern escarpment, weather with a remarkably dark, sometimes black, colour.[1] (Plate V.) The dip of the series is here about 20° N.

δ. ACTEONELLA-NERINEA LIMESTONE.

Owing to its highly fossiliferous character this bed is usually easily recognizable. The sudden change from the last-mentioned almost unfossiliferous series to beds practically composed of fossil shells is very striking. The predominant form is *Acteonella* (*Trochacteon*) *Salomonis*[2] Fraas, the individuals of which occur in countless millions; associated with it in large numbers is *Nerinea Requieniana* d'Orb.[3] In addition, as a rule, small and large, irregularly globular, semi-silicified masses of a peculiar organism are abundant, specimens of which have been determined by Dr. Gregory as a new genus *Millestroma Nicholsoni.*[4] Lastly, at times great reef-like masses of *Biradiolites cornu-pastoris* d'Orb., occur, often filling up the entire bed for many metres to the exclusion of the other more common fossils.

This highly fossiliferous limestone in some localities attains a thickness of 16 metres. In many, probably most, places it is underlaid by a band of gypseous shaly clay, and above by an additional thickness of less fossiliferous limestone. The whole series δ may be taken as having an average thickness of 35 metres.

In the Gaa range δ forms the slope from the pyramids westwards towards the dome of El Hassana. At the base of this slope it is lost owing to a fault, ending abruptly against the next series γ above. On the east side of the fault, its fossiliferous band, about 16 metres thick, is well seen in a small water-worn hollow.

---

[1] This colour is mainly due to iron, but may be intensified by the trace of manganese which is also present.

[2] "*Actæonella voluta* Münst." of Walther (*l.c.* p. 7.), Mayer-Eymar, Sickenberger and Fourtau. Blanckenhorn, however, has pointed out (*Neues z. Geol. u. Palæont. Ægyptens*, p. 37) while not referable to *A. voluta*, no less are they distinct from *A. Absalonis*, to which Fourtau has recently referred them (*Bull. Soc. Khéd. de Géogr.*, 1899, p. 191). Blanckenhorn in facts identifies them with *A. Salomonis* Fraas.

[3] *N. pyramidarum*, Mayer-Eymar, (*Zur Geologie Egyptens*), is without doubt *N. Requieniana*, d'Orb. See Bullen Newton, *Geological Magazine*. No. 411. Sept. 1898, p. 395.

[4] *Geol. Mag.* No. 410, August, 1898, p. 337-312. The author shows that the organism in question is a milleporoid coral, resembling in its general characters Stromatoporoid described by Nicholson as *Hermatostroma*. In other respects it is more closely allied to the genus *Millepora* and should in consequence be regarded as an intermediate form between the Palæozoic and Cainozoic Milleporoid Hydrocorallinæ.

The globular masses are as a rule very numerous in the bed in question, and frequently attain to nearly the size of a man's head. Whether the majority of these should be referred to *Millestroma* or to the bryozoan *Cerispora* (*C.* aff. *orbiculata*) is uncertain, and in the following pages organisms called *Millestroma* may in reality belong to the latter genus. On the plateau of Ghigiga, near the western end, probably in the same bed δ, coralline masses occur, forming large reefs several metres in width, and globular masses over 60 centimetres in diameter.

On the northern slopes of Gaa the series is several times repeated by faults. Near the village of Abu Roash, in the different faulted ridges, these beds are always to be seen, characterized by the usual fossils. In the dome of El Hassana, as already mentioned, the more or less unfossiliferous mass of limestones ζ forms the central core; this latter is surrounded on three sides by a narrow concentric valley cut out in the shaly clays at the base of the series δ, and contained by a ridge formed of the fossiliferous Acteonella-Nerinea limestones dipping at a high angle, and in places nearly vertical. Owing to a curious fault, the clays and limestone above are repeated immediately to the west of the dome, but a consideration of this may be left for the present.

A reef of *Biradiolites cornu-pastoris* is seen to perfection in the dome of El Hassana. (Plate X).

On the slopes to the south-east of El Qulaya the beds are also well seen, and again, as crystalline limestones, on the summit of Jebel el Ghigiga, near the western and southern ends, just before reaching the slope which descends to Sidr el Khamis.

In Jebel el Haggaf, forming part of the slope on the north side, the series can be detected by occasional shell-sections on the smooth surfaces of the highly crystalline limestones, and from its position under the overlying flinty limestones γ, which are easily recognizable in this locality.

At Jeran el Ful, the basal clays are represented by a thickness of thin-bedded shaly brown limestone, and the upper part by hard crystalline limestones in which bands of *Acteonella* and *Nerinea* are clearly seen, together with numerous globular masses of *Millestroma*. The total thickness is here 30-35 metres.

γ. FLINTY SERIES.

This well-marked series is characterized by the invariable presence of bands of flint, which have been largely quarried in almost all the localities where the beds are exposed. At Jeran el Ful the existence of ancient workings is shown by the accumulations of flakes which occur here and there along the outcrop of the beds. In numerous localities, especially on the eastern end of the hill-range, in the neighbourhood of Abu Roash, Gaa, and El Hassana, quarrying has continued until the present time, as late as 1898 men being engaged in opening up these

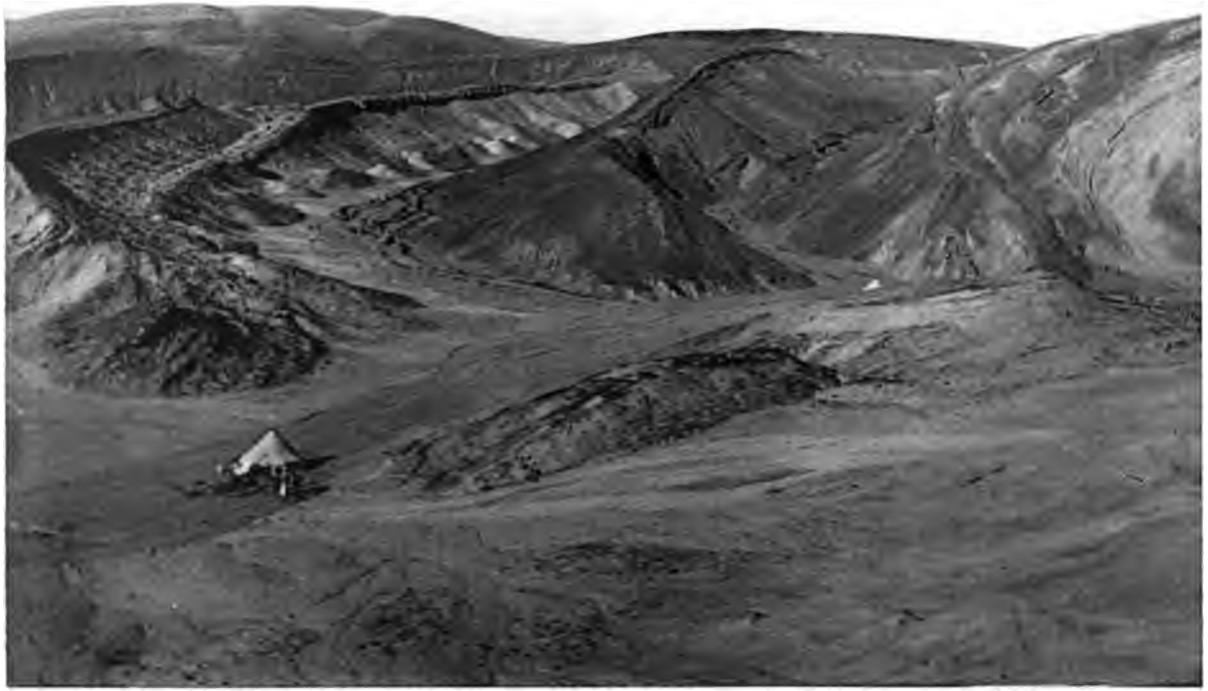


Plate VI. Part of the Dome of El Hassana.

beds for the purpose of obtaining the fresh flint for use in flint-lock guns. The work is now, however, almost abandoned, owing no doubt to the rapid displacing of flint-locks by percussion caps and breech-loaders among the natives.

The beds of this series are usually hard and compact white, often chalky, limestones, with thick and thin layers of flint. The most characteristic fossil is a coral, *Phyllocœnia Toucasi*,[1] which usually occurs abundantly in silicified masses as large as a cricket ball. The uppermost bed of the series, besides containing *Phyllocœnia* in abundance, is also generally very full of a small branched coral (?); with these are associated in smaller quantities globular masses of *Millestroma*.

The series has a thickness of 43 metres, and forms the top of the Turonian of Abu Roash.

It is found overlying the last series in all the localities mentioned, except where it forms a dip slope, as on the hill flanks west of Gaa pyramid, the higher beds having been removed by denudation. Near the village of Abu Roash, on the northern flanks of Gaa, at the dome of El Hassana, and in fact in most exposures, the flint bands contained by these limestones are seen to have been remarkably crushed, no doubt due to the intense pressure exerted during the extensive faulting and folding to which these beds have been subjected.

These brecciated flints are cut up by numbers of cracks in all directions into angular fragments, which, varying as they do in the depth of their colour, give the bands a remarkably peculiar appearance.

At Jeran el Ful the series forms the southern slope of the mass of hard crystalline beds, immediately overlooking the valley cut out in the overlying softer beds.

On the south and west sides of Jebel el Ghigiga the series forms the slope from the summit down to the depression of Sidr el Khamis. At Jebel el Haggaf these flinty beds are found at the base of the northern slope, forming the last hard bed, dipping under the soft beds of the series now to be described (See Section VII).

SENONIAN (SANTONIAN).

β. OSTREA AND PLICATULA BEDS.[2]

These beds, being soft in character, are always found occupying the low ground, having suffered denudation to a considerably greater extent than any of the other series. Occasionally forming fairly compact limestones, although never rendered crystalline like the underlying beds, the series is, as a rule, marked by the presence of soft marls, sometimes clayey, and often sandy. Owing to their method of occurrence in the depressions, often weathering to a dead level surface, it is a matter of some difficulty to estimate their true thickness. An examination however, at many points gives an average thickness of 58 metres, although there is no hard and fast line between them and the White Chalk above. They are throughout characterized by the presence of large massive oysters of different species, the shells of which are often replaced by beekite; the chief forms are the following[1]:—*Ostrea acutirostris* Nilss, *O. Heinzi* Thom. et Per., *O. Bourguignati* Coq., *O. dichotoma* Bayl., *O. Costei* Coq.,[2] *O. proboscidea* d'Arch.[3] These, as well as the other fossils occurring in these beds, are always well preserved and usually abundant. The lower beds of the series, which sometimes appear as fairly hard limestones, are always conspicuous by the numerous individuals of *Plicatula Ferryi* Coq., which probably, however, occurs sparsely in the upper beds of the series as well.

---

[1] A specimen sent to the British Museum, but apparently not collected from a definite horizon, was determined by Gregory as *P. Toucasi*. De Fromentel, var. *Ægyptiaca*. (*Geol. Mag.*, June. 1898, No. 408, p. 250–251). Bullen Newton has since examined specimens collected from the Flinty Series and confirmed the above determination. The variety appears to be closely allied to *P. Pomeli*, Thom. and Peron.

[2] Schweinfurth's ζ and ε. Vide Peterm. Mitth., 1889.

Always abundantly associated with *Plicatula Ferryi* are small aggregations of minute *Serpulae* tubes (*Galeolaria filiformis*).[4]

Echinids are often abundant, and of them *Hemiaster*[5] is the commonest genus. The Plicatula Beds at the base are followed by softer marly beds containing harder brown-coloured bands of limestone. These brown beds are sometimes 15 metres thick.

Above them come the grey beds, characterized by bands of hard friable grey or greenish marly, or sometimes sandy, limestone. At the base of these is a band with numerous specimens of beautifully preserved

---

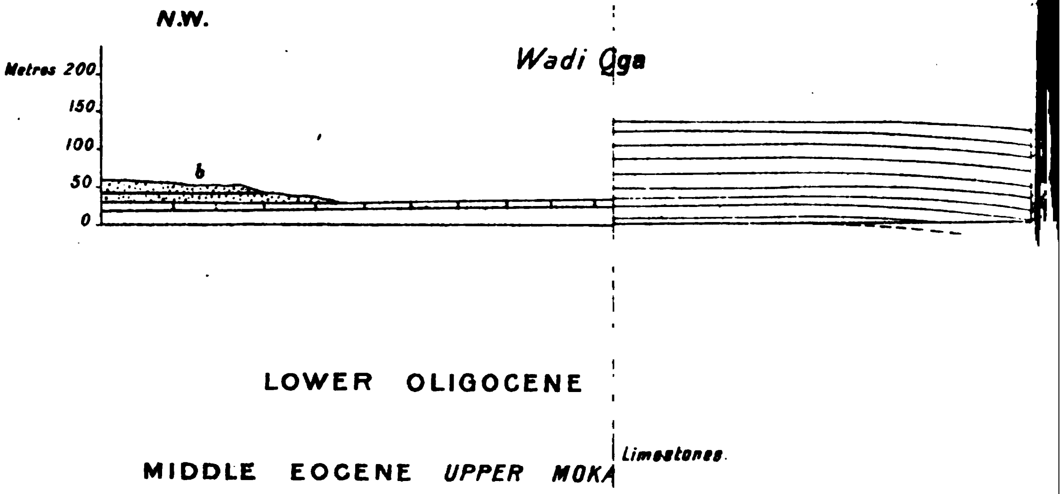
[1] See also Blanckenhorn, *loc. cit.* p. 39.

[2] Specimens of this form from Abu Roash (El Qulaya) are described by Bullen Newton (*Geol. Mag.*, No. 411, Sept. 1898, page 399–400) as *Gryphæa Costei.*

[3] Fourtau ("Échinides Fossiles" etc., p. 16) records the following oysters from these beds:—*Ostrea Brossardi* Coq., *O. Boucheroni* Coq., *O. Peroni* Coq., *O. Costei* et var *hippopodium* Coq., *O. dichotoma* Bayle et var *acanthonota* Coq., *O. lateralis* Nilss, *O. laciniata* Lam., *O.* cf. *plicata* Perm.

[4] Similar aggregations of *Galeolaria filiformis* occur in the Cretaceous of Baharia in beds almost undoubtedly Cenomanian.

[5] The following species have been recorded from this series of beds (Fourtau *loc. cit.* p. 17–24) *Rhabdocidaris Crameri* de Loriol, *Salenia Fraasi* Cotteau, *Orthopsis miliaris* (d'Archiac) Cott., *Cyphosoma Abbatei* Gauthier, *Holectypus excisus* Desor, *Hemiaster Blan(c)kenhorni* Gauth. It seems a pity, considering the confusion already existing in the nomenclature of their science, that palæontologists should further increase it by the careless spelling of names, when recording new species. Two new species in the work referred to, i.e. *Hemiaster Blankenhorni*, Gauth., (p. 23) and *Mistechinus Sickembergeri* Gauth., (p. 32), in either case have the specific name wrongly spelled, in spite of the fact that both are named after well-known geologists, one "notre ami" and the other "notre excellent confrère" of the author. *Hemiaster Fourneli* Desh., also occurs, according to Blanckenhorn (*loc. cit.* p. 39).


N.W.
Metres 200
150
100
50
0
b
Wadi Qga
LOWER OLIGOCENE
MIDDLE EOCENE UPPER MOKA
Limestones.

Echinobrissus Waltheri Gauth.,[1] and at the top occurs a bed containing, in places, very numerous Ammonites,[2] probably of several species. The only species which appears, however, to have been actually recorded is *Tissotia Tissoti* Per.[3] The grey beds are not constant in thickness in different localities; they always, however, pass up into the White Chalk. The series is best developed in Sidr el Khamis, which depression is due in great part to the softness of these beds. At the base of the slopes of Jebel el Ghigiga, on the west and south sides, and of Jebel el Haggaf on the north side, this series, beginning with the Plicatula Beds, is always found overlying the flinty series γ. The upper beds, including the *Echinobrissus* and Ammonite bands, are best seen near the base of the chalk cliff in the south-western corner of Sidr el Khamis, where they are observable running concentrically for a long distance, like the tiers of an amphitheatre.

At Jeran el Ful the low valley bounding the crystalline ridges on the south side is entirely formed of these beds, and many of the characteristic fossils may there be obtained. The upper beds are not, however, exposed, the overlapping Eocene series hiding the Ammonite band entirely.

Between El Qulaya and the slopes of the main hills this series is also well seen, the flinty series with a dip of 12° being followed by the *Plicatula* bands, then the brown, and finally the grey beds,[4] the latter passing into the White Chalk. Some of the beds here contain large lamellibranch casts.[5]

Immediately to the south of the dome of El Hassana, following on the outer concentric limestone ridge formed of the flinty series, the different beds of β are seen outcropping on the almost level ground. The upper grey beds are, however, hardly exposed, and the Ammonite band was not met with.

Along the base of the northern flanks of Gaa this series is found, as a rule, well developed. Near the bottom of the inclined roadway leading up to the Gaa pyramid, the outcrops of the different members of β are seen to run round from one side of the road to the other in U-shaped curves, a section at right angles to the road showing an anticlinal fold with dips of 20–22° on either side. On the south side of the road the lower beds are particularly rich in *Plicatula Ferryi.*

---

[1] Fourtau, *loc. cit.* p. 21-22.

[2] I have only found ammonites in these beds in Sidr el Khamis; Walther however records them from El Qulaya, where the same beds are undoubtedly exposed.

[3] Walther however suggests that these badly-preserved ammonites are referable to *A. Fourneli* Coq., (*loc. cit.* p. 9).

[4] Walther (*loc. cit.* p. 9), records ammonites from this locality.

[5] *Janira tricostata*, Bayl has been recorded from this series.

Lastly, the series is found in the several faulted ridges of highly inclined beds near the village of Abu Roash, here, as elsewhere, the beds, owing to their soft character, occupying the low ground in the valleys rather than the higer ridges.

The soft marly chalk which I have recorded as being seen outcropping in the valley below the Eocene escarpment, half-way between the Pyramids of Giza and Jeran el Ful, probably belongs to this series β.

SENONIAN (CAMPANIAN?) TO DANIAN.

α. WHITE CHALK.

The grey Ammonite-bearing bed of the last series, as already mentioned, passes up almost immediately into white chalk. Near the base, and also frequently higher up, the latter is of a somewhat shaly nature, but taken as a whole it has all the characters of a true chalk. The basal beds have a peculiar habit of suddenly becoming hard and crystalline, forming a rock made up entirely of perfectly formed zoned rhombohedra, of a light greenish or yellowish colour, weathering black. The passage from soft white chalk into this hard crystalline dolomite[1] occupies only a space of a few metres and is well seen at El Qulaya and at the base of the slopes of Ghigiga, 300 metres to the south. Weathering has left these masses of hard dolomite standing up as hills where the surrounding softer chalk has been worn down, and this is the cause of the existence of the peculiar hill of El Qulaya, and of another similar hill on exactly the same horizon in the south-west corner of Sidr el Khamis. Both Walther and Schweinfurth appear to have fallen into the peculiar error of taking this rock for sandstone, as the former speaks of the "grès de Golea"[2] and in his sections shows that hill as being formed of sandstone. The latter writes[3] "The centre of Golea has a peculiar sandstone hillock....... which bears this name."

---

[1] A sample of this rock has since been analyzed by Mr. Lucas; this confirms its dolomitic character:

$Si\,O_2$	trace.
$Fe_2\,O_3$ and $Al_2\,O_3$	1·00
$Ca\,CO_3$	59·57
$Mg\,CO_3$	39·42
$Ca\,SO_4$	trace.
	99·99

[2] "Le grès jaune foncé ou grisâtre" (*loc. cit.* p. 9, and section-plate facing p. 6). Blanckenhorn also, probably deriving his information from Walther, also speaks of sandstone as occurring on this horizon (*loc. cit.* Tabelle and p. 44.)

[3] *Loc. cit.* "Pet. Mitt.," pl. 2.

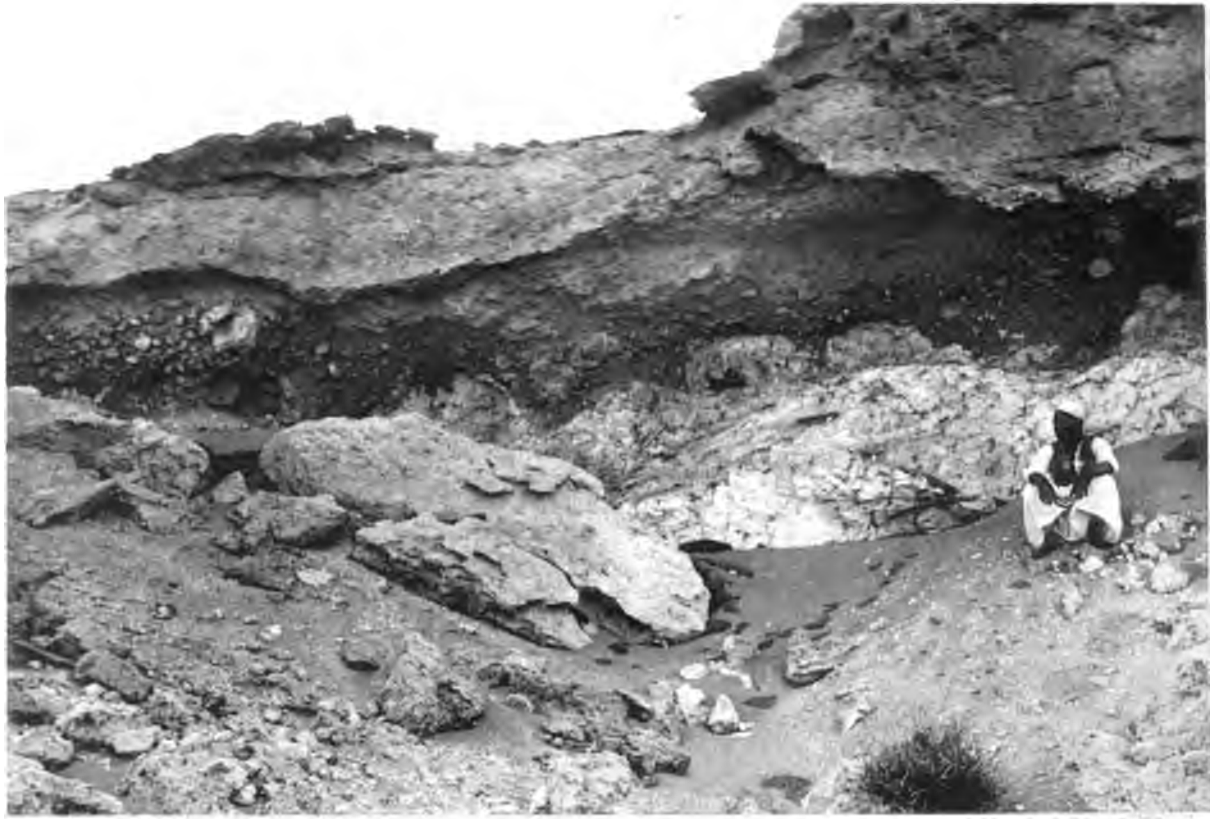


PLATE VII. UNCONFORMABLE JUNCTION OF EOCENE AND CRETACEOUS.
CLIFF ON WEST SIDE OF SIDR EL KHAMIS.

Near the base of the White Chalk nodules of limonite are of somewhat frequent occurrence. Fossils are not at all common, but a close search reveals the presence of numerous small and medium sized *Ostrea*, *Gryphæa vesicularis* Lam., together with occasional *Exogyra* cf., *Langloisi*, *Spondylus* sp., and *Pecten* sp. (*Pecten farafrensis?*) Simple corals (*Cœlosmilia laxa*) occur, especially in the highest beds, and these are apparently identical with those found in the White Chalk of Baharia,[1] which is the continuation of that of Farafra Oasis, where it was examined by Zittel and classified as Danian. Some of the other fossils from the two areas are also identical, but they have not yet been specifically determined. Lithologically the White Chalk of Abu Roash is exactly similar to that of Baharia and in both areas is unconformably overlain by the Eocene.

In places the highest beds become pepper-coloured and earthy, and on this horizon single corals frequently occur. Large *Serpula* tubes also are present and one mass of Rudistæ (*Biradiolites?*) was obtained; the occurrence of *Gigantichthys pharao*, Dames, is also noteworthy.

There are two chief localities where series α occurs, the first and best being the cliff surrounding the depression of Sidr el Khamis on the west and south-west, and continued northwards; secondly, the low valley, part of Wadi el Qurn, bounding the hill masses of Ghigiga and Gaa on the north. In this latter locality the snow-white chalk forms a flat plain of considerable extent, rising only a few metres in height on its northern boundary as it passes under the overlying Eocene beds.

At the bottom of the Gaa pyramid road the White Chalk, folded into a well-marked anticline, follows round the series β from the north to the south side and occupies a small area southwards until cut off by a fault against the first ridge of highly inclined lower rocks. It also occurs in the valley south-west of the centre of Abu Roash village, overlying the *Ostrea* and *Plicatula* beds (see map and sections). This White Chalk, like the series β below, is never found, except very locally, to have been rendered crystalline, as has the great central mass of Cretaceous beds, formed of the series ε, δ and γ.

The White Chalk has a thickness of 100 metres, and still higher beds[2] are hidden by the overlying Eocene rocks.

---

[1] *Découvertes géologiques récentes*, etc., pp. 4 and 14.

[2] Probably these unexposed beds represent the higher part of the White Chalk of the Oases, which often contains *Ananchytes ovatus*. Schweinfurth (*loc. cit.* p. 2) says the Abu Roash Cretaceous is marked especially by the absence of this fossil; but as I have shown, this uppermost White Chalk is almost certainly the equivalent of the White Chalk of the Oases, which in places, although rather rarely, contains *Ananchytes ovatus*.

The following are detailed sections across at Jeran el Ful and Jeb
el Haggaf:—

CRETACEOUS SUCCESSION AT JERAN EL FUL.

(The numbers of beds refer to Section VI., from which thicknesses, etc., can be obtained).

η. SANDSTONE AND CLAYS. (30 metres thick.)

Base.

1. Fine white angular siliceous sand.
2. Dark-brown friable sandy limestone.
3. Yellowish or white sand.
4. Dark-brown hard friable sandy limestone.
5. Yellowish-green saliferous clays.
6. Greyish-blue sandy saliferous clays.
7. Hard yellowish-brown sandy limestones with calcite druses; upper part friable.
8. Hard-bedded yellow or brown sandstone.

ζ. RUDISTÆ BEDS. (40 metres.)

9. Greyish sandy clays with thin bands of shaly sandstone.
   One half-metre band of brown sandy limestone with numerous shell-casts.
10. Hard yellowish, grey-weathering, crystalline limestone with numerous *Biradiolites*.
11. Hard white or brown crystalline limestone.
12. Hard yellowish thin-bedded, often crystalline, limestone.
13. Hard closegrained light-yellow or white crystalline limestone.

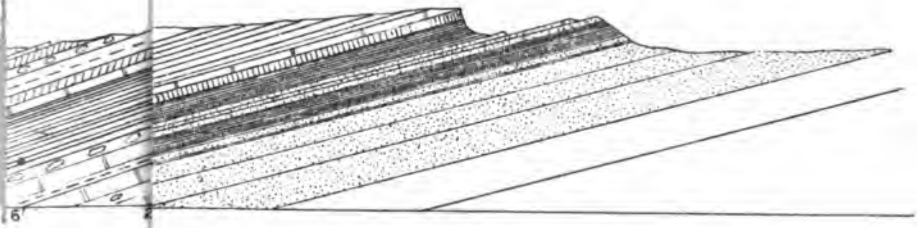
ε. HARD COMPACT AND CHALKY LIMESTONES (Crystalline in this area). (130 metres.)

14. Hard crystalline limestones with casts of gastropods, probably *Acteonella.*
15. Grey coarser crystalline limestone showing small shell-sections.
16. Close-grained compact hard finely-crystalline limestone.
17. Hard brown, white, and grey crystalline limestone. These are the hardest beds and often resemble the finest marble. Interbedded are some brown-coloured bands of closer-grained splintery (siliceous) limestones.
18. Ditto, with numerous *Acteonella* and *Nerinea.*
19. Close-grained hard, rather siliceous, limestones with some flinty bands.
20. Softer, mostly compact, white limestone.
21. Hard brown splintery, and probably siliceous, limestone.
   Hard white to grey marble. Coarsely-crystalline, very hard, grey limestone, with close-grained white bands.
22. Crystalline limestone with *Acteonella* and *Nerinea.*
23. Hard grey crystalline limestone, weathering black, with band showing sections of *Acteonella* and *Nerinea.*
24. White close-grained, often crystalline, limestone.
25. Dark and light grey ditto, with occasional brown bands. Sometimes a band with shell-sections is seen; also nodular masses of *Millestroma.*

SECTION VI

SECTIO

N.



Vertical Scale $\frac{1}{2000}$

numbers 0 200 300 Metres

26. Dark-brown crystalline limestone with flint layers.
27. White crystalline limestone, shell-sections.
28. White crystalline limestone with occasional shells and masses of *Millestroma.*

δ. ACTEONELLA NERINEA BED. (34 metres.)

29. Hard compact yellowish limestone.
30. Thin-bedded shaly brown limestone band.
31. Hard reddish-brown crystalline limestone.
32. Hard white siliceous *Acteonella-Nerinea* limestone.
33. Close-grained limestone with flint band.
34. Hard crystalline limestones with masses of *Millestroma.*
35. Hard buff semi-crystalline limestone with *Acteonella* and *Nerinea.*
36. Fine-grained crystalline limestones.
37. Hard yellow gritty limestone.

γ. FLINTY SERIES. (32 metres.)

38. Soft sandy beds with gypsum and small *Ostrea* sp.
    Soft white limestones with casts of lamellibranchs, *Ostrea*, etc.
39. Hard yellowish, rather crystalline, limestone. Band of flint.
    Hard white limestone, with small branching corals and some *Millestroma.* Flint bands. *Phyllocœnia Toucasi* numerous, but always silicified.
40. Hard yellowish compact limestone, grey below.

β. PLICATULA AND OSTREA BEDS. (62 metres).

41. Soft yellowish-white limestone with *Plicatula Ferryi*, *Serpulæ* bundles, *Ostrea*, *Hemiaster* and other echinids.
    Bed sometimes harder and shelly.
42. Soft marls and marly limestones with occasional hard and crystalline bands; the latter, however, do not often remain crystalline for more than a few metres.

The above are unconformably overlaid by the following Upper Mokattam (Middle Eocene) beds. (12 metres).

I. Grey or brown, grey-weathering, limestone-grit full of small *Nummulites*, etc. This bed often passes into a conglomerate at its base, containing rounded pebbles of hard Cretaceous limestone and large worn *Ostrea*, derived probably from Cretaceous beds immediately below. Casts of shells and occasional echinids occur in this bed.
II. Similar to last but contains casts of shells more abundantly; pebbles smaller and less frequent.
III. *Ostrea* bed.
IV. Hard dark-weathering brown limestone, rather gritty, with casts of shells. Sandy limestone in part. Passes up into purer limestone without sand-grains.
V. Hard yellowish-brown limestone full of shell-casts (forms top of escarpment) and covered with loose rounded pebbles, forming an undulating desert.

CRETACEOUS SUCCESSION ON THE SOUTHERN ESCARPMENT OF JEBEL EL HAGGAF.

(The numbers of beds refer to Section VII).

η. Sandstones and Clays. (30 metres.)

Base.

1. Reddish-brown sandstone.
2. Hard brown sandy limestone with casts of shells.
3. Brown sandstone and sandy limestone.
   Sands and sandy clays. Brown sandstones, often calcareous, full of shell-casts. Grey and yellow sands alternating with hard brown sandstones.

ζ. Rudistae Beds. (42 metres.)

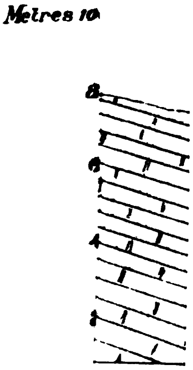
4. Grey, rather ferruginous, clays. Buff-coloured marls.
5. Hard yellowish-white semi-crystalline limestone with a few shells, seen in section, near top.
6. Soft white broken-up friable limestone with numerous small echinids (*Cyphosoma Abbatei*) and casts of shells.
7. Thin-bedded shaly limestone with shelly bands.
8. Grey white marly limestone. Band of small *Ostrea.*
   White friable limestone with thin bands of *Ostrea.*
   Hard buff friable marly limestone. Hard white friable limestone.
9. Grey iron-stained clays with salt and gypsum. Brown ditto.
   White marly limestone.
10. Hard friable grey-white limestone, marly at top, with thin bands of gypsum.
11. Well-marked band of hard white, somewhat crystalline, limestone with bands containing small Rudistæ and small shells. This limestone has often a pitted oolitic appearance. More friable limestone.
    Hard yellowish marly clay with small shells.

ε. Hard Compact and Chalky Limestones (often crystalline). (140 metres).

12. Friable and white marly limestone with bands of flint in upper part.
13. Hard white bedded limestone forming a prominent band. Poor examples of *Acteonella* and *Nerinea* at its base. This bed a little to the west becomes somewhat hard and crystalline and weathers black.
14. Friable white limestone with *Acteonella* and *Nerinea.*
15. Friable, passing up into thin-bedded, limestone, hard and greyish-white. Hard, rather crystalline, limestone.
16. Hard white limestones, semi-crystalline, friable and thin-bedded.
17. Hard white limestone, semi-crystalline, with flints. Passes at times into hard brown, black-weathering, highly-crystalline dolomite.
18. Grey to brown, black-weathering, hard and highly-crystalline limestones.

Above this, at base of escarpment facing north, follow δ (Acteonella-Nerinea Bed), γ (Flinty Series) and β (Plicatula and Ostrea Beds).

H



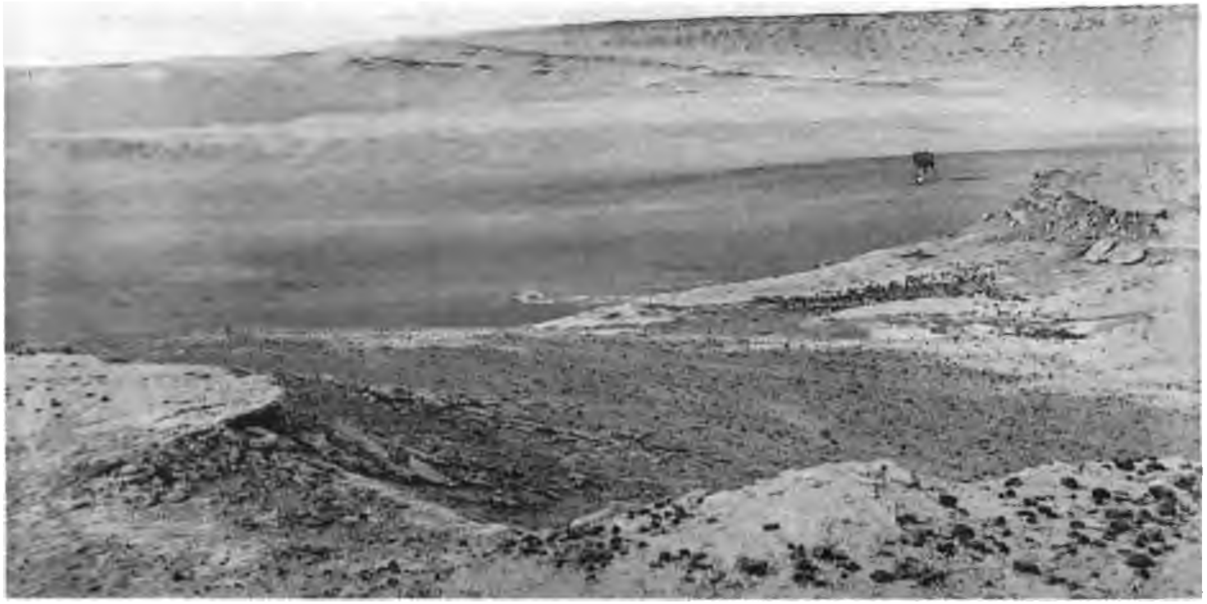


PLATE VIII. JUNCTION OF EOCENE AND CRETACEOUS IN SOUTH-WEST CORNER OF SIDR EL KHAMIS.

The following comparative table shows at a glance the general relations of the Cretaceous strata in the different parts of the Libyan Desert examined by the writer:—

TABLE OF CRETACEOUS STRATA IN THE LIBYAN DESERT AND NILE VALLEY.

			ABU ROASH.	BAHARIA OASIS.	DAKHLA OASIS.	NILE VALLEY.*
CRETACEOUS.		DANIAN.	White Chalk with corals, *Exogyra* cf. *Langloisi*, *Gryphæa vesicularis*, *Spondylus*. *Pecten*, *Rudistæ*, etc.	White Chalk with corals, *Gryphæa vesicularis*, *Exogyra Overwegi*, *Pecten farafrensis*, *Corax pristodontus*, etc.	White Chalk with corals. *Ventriculites*, *Ananchytes ovata*, *Gryphæa vesicularis*, *Pecten farafrensis*, etc. Greenish and ash-grey leafy clays.	
	SENONIAN.	CAMPANIAN.	Part of White Chalk? Marls and limestones with *Tissotia Tissoti*. *Ostrea Costei*, *O. dichotoma*, etc.; *Echinobrissus Waltheri*. Marls with *Plicatula Ferryi*. Flinty limestones.	Probably some of the intermediate beds are Senonian or Turonian.	Bone-beds. Nubian clays and sandstones.	*Trigonoarca* and *Ptychoceras* beds. Bone-beds. Nubian clays and sandstones.
		SANTONIAN.				
		TURONIAN.	Limestones with *Nerinea Requieniana*, *Acteonella Salamonis*, *Biradiolites cornu-pastoris*, *Millestroma Nicholsoni*.			
		CENOMANIAN.	Limestones with *Cyphosoma Abbatei*, *Hemiaster roachensis*. *Sphaerulites*, *Radiolites*, etc. Clays and sandstones.	Limestones and variegated sandstones with *Hemiaster roachensis*, *Heterodiadema libycum*, *Neobolites Vibrayeanus*. Sandstones and clays with *N. Vibrayeanus*, *Exogyra flabellata*, *E. Mermeti*, and *E. olisiponensis*.		

(*c*) **Tertiary deposits.**

Having described at some length the different beds of the Cretaceous I shall now very briefly refer to the younger formations by which they are surrounded.

MIDDLE EOCENE.

The outer limit of the Cretaceous is throughout, a distance of about 28 kilometres, bounded by beds of Middle Eocene age, the junction of which has now been shown to be one of unconformability, not of faulting as formerly supposed. In the neighbourhood of the Pyramids of Giza the Eocene is represented by both Upper and Lower Mokattam,[1] the latter characterized by the abundance of the large *Nummulites gizehensis* Ehr., and the former by the large flat *Carolia placunoides*[2] and other fossils.

---

* The Nile Valley succession is that obtained by my colleagues Messrs. Barron and Hume, on the right bank of the Nile.

As already shown, at one point only, about 4 kilometres west of the Pyramids, is the lower, the *Nummulites gizehensis*, series, found overlying the Cretaceous beds, and here the junction is not visible. To the north of this, before Jeran el Ful is reached, the upper beds overlap the lower and themselves overlie the Cretaceous.

Except in the neighbourhood of the Great Pyramids the Middle Eocene outcrop is usually only of very small extent, forming a narrow band frequently only several hundred metres wide; on the north boundary a breadth of only a few metres is exposed. The thickness of the series is also slight, usually not exceeding a few metres, suggesting the idea that these beds were laid down along a shore-line of subsiding Cretaceous

---

[1] TABLE OF OLDER TERTIARY STRATA IN THE NILE VALLEY AND FAYUM, ETC.

LOWER. OLIGOCENE.			Sandstones and sandstone-grits with silicified wood; *Lanistes transiens*. Basalt sheets at base, contemporaneous and interbedded.
UPPER EOCENE.	BARTONIAN.		The lower part, probably nearly up to the basalt sheet, of the great (200 metres thick) fluvio-marine series of the Fayum, with *Unio*, *Lanistes*, *Melania* and *Cerithium*, and silicified wood, and an abundant mammalian and reptilian fauna, especially near the base. Siwa Oasis series,[3] with *Nummulites Fichteli*, *N. intermedia*, *N. Rutimeyeri*, and *Orbitoides papyracea*.
MIDDLE EOCENE.	PARISIAN.	Upper Mokattam.	Limestones, clays and sandstones, with *Carolia placunoides*, *Ostrea Fraasi*, *O. Clot Beyi*, *Cardita Ægyptiaca* *Echinolampas Crameri*, *Qerunia cornuta*, etc., and a rich vertebrate fauna in the Fayum.
		Lower Mokattam.	Limestones, clays, etc., with *Nummulites gizehensis*, *N. Beaumonti*, and *N. curvispira*, *Carolia placunoides*, *Zeuglodon Osiris*, etc., etc.
LOWER EOCENE.	LONDINIAN.	Upper Libyan.	*Callianassa* beds; *Alreolina* limestones.
	SUESSONIAN.	Lower Libyan.	Limestones with *Operculina libyca*, *Lucina thebaica*, *Nautilus Forbesi*.
	FLANDRIAN.	Esna Shales.	Clays and shales with *Nucula*, *Leda*, *Aturia* and *Nautili*.

[2] This fossil is not, however, absolutely confined to the upper division, as at Beni-Hassan, Minia, Wadi-Rayan, etc., *Carolia placunoides* and *Nummulites gizehensis* occur together.

[3] The relation of this series to that of the Fayum has not yet been determined.

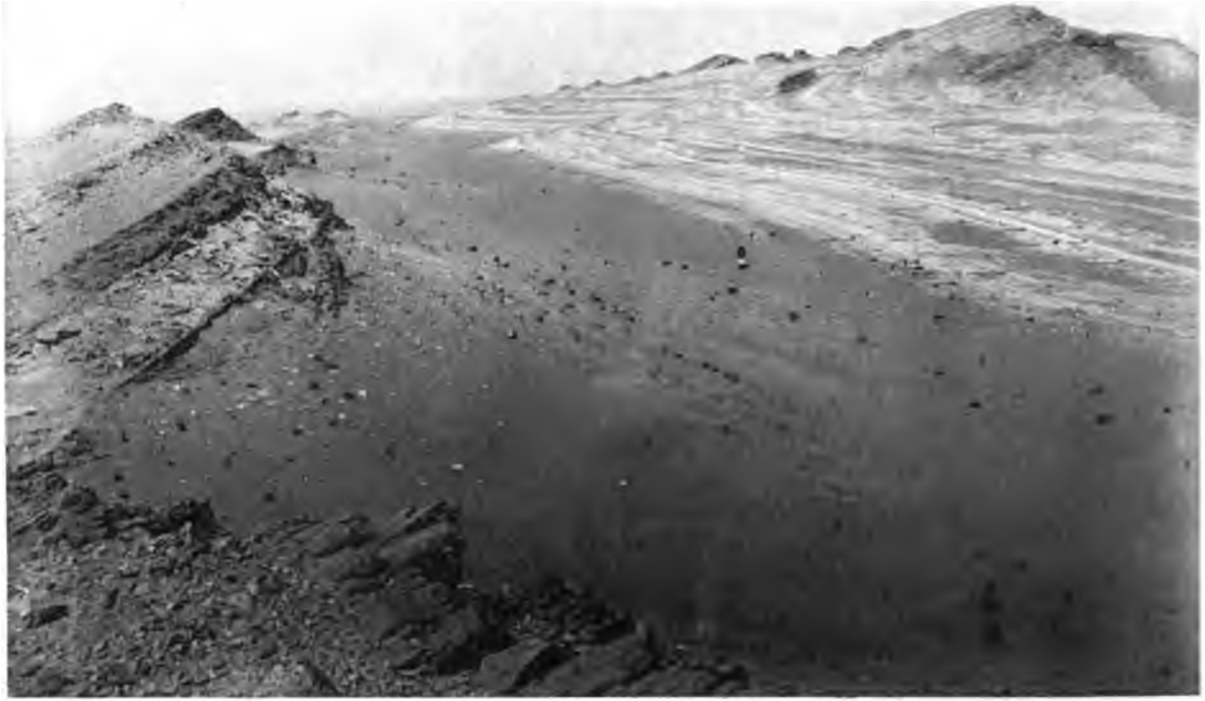


PLATE IX. CRYSTALLINE LIMESTONES OF JERAN EL FUL.

land towards the close of the period of deposition of the Mokattam series, especially as they are followed immediately by the sands and sandstones of the next formation.

UPPER EOCENE AND LOWER OLIGOCENE.

The Upper Eocene here, as at Jebel Mokattam east of Cairo, is wanting, or at most represented by a few metres of sandstone. As will be seen from the table of Older Tertiary strata given above, in the central part of the northern escarpment of the Fayum the Upper Mokattam is overlain, perfectly conformably, by an immense thickness of arenaceous and argillaceous strata, which, while for the most part unfossiliferous, occasionally contain sufficient organic remains to show the series to have been laid down in a decidedly estuarine area; the great quantities of trees and the remains of numerous land mammals likewise indicate the existence of rivers emerging from the land. In the upper part of the series intercalated sheets of basalt occur very persistently along a certain horizon, above which the series continues unaltered in lithological character. The few fossils which were obtained, however, show that, while those well below the basalts are decidedly of an Upper Eocene facies, as we approach the igneous outpourings forms of a more Oligocene character occur, while above the basalts species of true Oligocene age appear to exist. It is in fact quite certain that the transgression from Upper Eocene to Oligocene is perfectly gradual, the series being one of absolutely continuous deposition. The presence of persistent intercalated sheets of basalt in the series, in an intermediate position between beds containing forms undoubtedly referable to the Upper Eocene and Lower Oligocene respectively, offers an ideal point at which to draw the junction although naturally of an arbitrary nature, between the two formations for purposes of description and mapping.

The presence in the Abu Roash region of exactly similar basalts in exactly similar sands and sandstones makes it highly probable that they are on the same horizon as those of the Fayum, especially as they can be traced over considerable areas in the intervening desert.

At Abu Roash the basalts almost immediately overlie the Upper Mokattam beds, being at most separated by a metre or two of intervening sandstone. Thus we see that the great mass of the Upper Eocene (as developed in the Fayum) is practically excluded in this area, being at the best represented in its highest part by the small thickness of sandstones occurring below the basalts near the Cretaceous boundary, and further north towards Kom el Khasshab. The disappearance of such a thickness (200 metres) between the Fayum and Abu Roash is at first sight somewhat surprising, but it should be remembered that the series is largely of fresh-water or estuarine origin, and such deposits are liable to be local, showing great thicknesses in certain areas and rapidly thinning out when traced into others. It is at least evident that the supply of sediment to the area under discussion was small, probably partly owing to the locality being one of shallow water, the shore line of the Cretaceous land-mass of Abu Roash. The absence of the lower part of the series may be further explained by a continuous overlap of the beds of the formation between the Fayum escarpment and Abu Roash.

To the west of Sidr el Khamis, towards the well-marked hills of Kom el Khasshab, the lower beds of the series are hard coarse, dark-coloured, silicified, ferruginous grits and soft white and yellow sandstones.[1] Some bands have undergone considerable silicification and present the appearance of typical quartzites Above these lower beds come interbedded contemporaneous basalt sheets, four or more metres thick, generally decomposed to a soft greenish clayey rock. The basalts usually contain an abundance of chalcedony veins[2] and a bright green mineral.[3] Above, more sandstones occur, and these are characterized by the quantities of silicified wood. A large tree near Kom el Khasshab measured between 70 and 80 centimetres in diameter, and had probably been over 20 metres in length. The thickness of the whole series above the Mokattam beds may be estimated very approximately as 40–50 metres.

At the extreme north-west corner of the Cretaceous area, the beds of the latter, dipping at about 20° to the north, are overlaid by one or two metres of Eocene limestone-grit, dipping at 2–3° in the same direction. The outcrop of the latter is about 100 metres wide, beyond which follows on a band of basalt covered by sandstones.

Near the village of Abu Roash the Mokattam beds, overlying the White Chalk on the western boundary, are themselves immediately overlaid by a series of alternating sands and grits with sheets of amygdaloidal basalt and interbedded volcanic ash and tuff, the latter often largely mixed with quartz sand-grains. The series forms low rounded hills covered by later superficial deposits of loose gravel.

---

[1] Schweinfurth (*loc. cit.* p. 2) mentions these beds as containing characteristic fossils of the uppermost Parisian, but it is not quite clear to me in what sense the latter term is used.

[2] These hard veins are frequently left standing like small dykes above the surface of the ground owing to the differential action of weathering.

[3] Analysis shows this mineral to consist largely of carbonate of lime:
SiO_2 and insoluble 10·94, Fe_2O_3 and Al_2O_3 4·12, $CaCO_3$ 82·50, $CaSO_4$ 0·41.

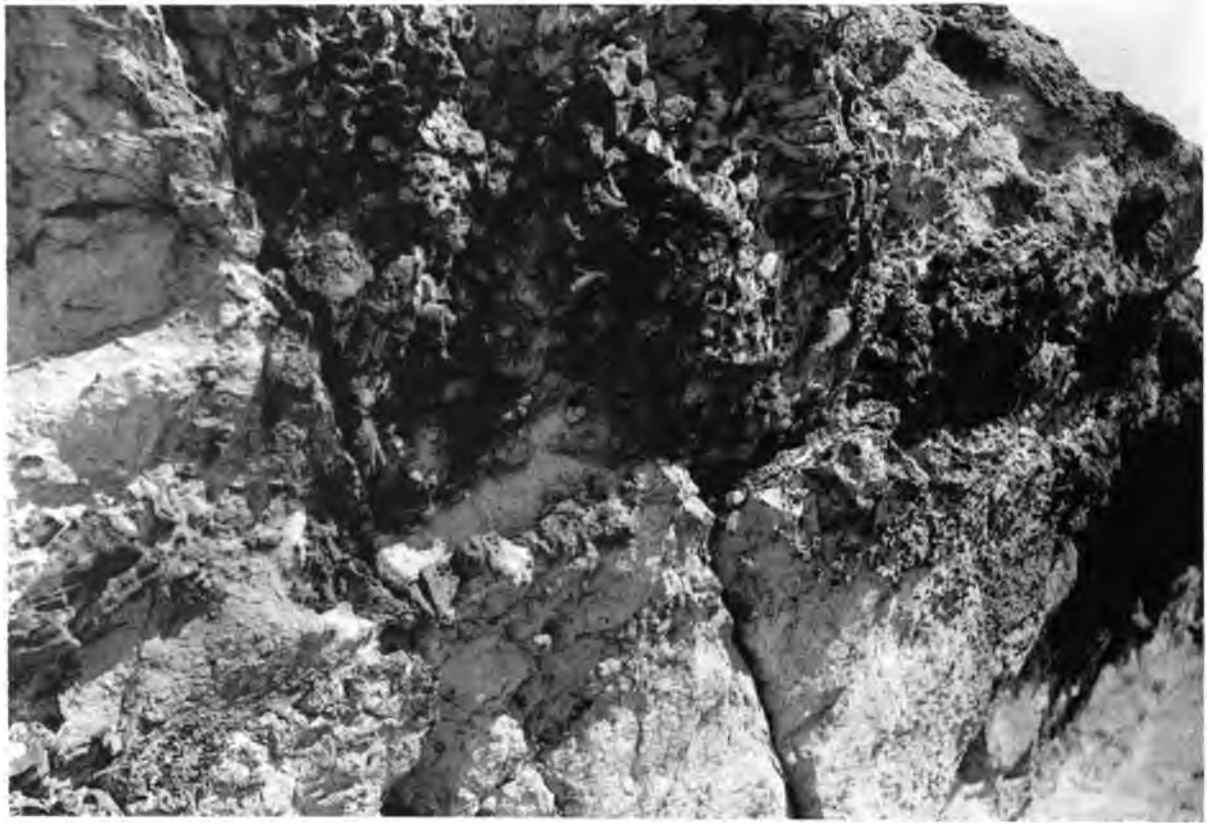


PLATE X. BANK OF BIRADIOLITES CORNU-PASTORIS D'ORB.,
TURONIAN OF DOME OF EL HASSANA.

PLIOCENE.[1]

The well-known *Clypeaster Ægyptiacus* beds, which occur to the south of the Pyramids of Giza, have not yet been noticed in this area.

The low-lying gravel-covered hills of Wadi Talun, between the Pyramids and Gaa, consist largely of sands and sandstone with occasional carbonaceous and ferruginous clays, often thirty metres or more in thickness, although owing to the thick superficial accumulations of loose rounded flints and sand, these beds are seldom exposed. They appear certainly not to belong to the Cretaceous and their position suggests a Pliocene age; fossils, however, have not yet been obtained from these deposits.[2]

The numerous borings found in the district, and noticed by most writers on Egyptian geology, may probably be safely regarded as dating from the time of the Pliocene sea; they occur chiefly along the northern escarpment of the plateau of the Great Pyramids. The hard, rather crystalline, limestones of this cliff are in places perforated like a sponge with thousands of parallel or slightly converging cylindrical cavities horizontally placed, of 2–3 centimetres diameter and 5–7 centimetres long. The preservation of these borings proves that denudation has effected little on the hard limestones of this cliff, but it is quite possible that it may have remained covered by later deposits until comparatively recent times.

Fragments of Cretaceous limestone containing similar borings are of frequent occurrence at the base of the southern flanks of the Gaa range, but they have not there been found on rocks *in situ.*

PLEISTOCENE AND RECENT.

The thick superficial accumulations of perfectly rounded quartz and flint pebbles[3] which cover the lower parts of the district must be of this age. These loose deposits are chiefly noticeable as forming the surface of the undulating hills of the area between the pyramids and Abu Roash.

Small quantities of igneous pebbles also occur in these gravels.

---

[1] No deposits of Miocene age have been identified north of the Pyramids of Giza in this region.

[2] The occasional fragments of red breccia which are met with, although not yet *in situ*, are interesting as suggesting similar conditions here as occurred throughout the Nile Valley in these times, where the formation of an exactly similar rock was very constant along the lake-margins.

[3] It is interesting to note that while the flints on exposure become mostly split up by changes of temperature, etc., the white quartz pebbles nearly always remain perfectly intact. The pebbles are probably largely derived from the denudation of the Oligocene deposits occupying the higher ground between Abu Roash and the escarpment of the Fayum.

The following determinations have been made by Mr. R. Bullen Newton, F.G.S., of the British Museum (Nat. Hist.).

	OLIGOCENE.
LOWER OLIGOCENE.	*Lanistes transiens.*
	EOCENE.
MIDDLE EOCENE (PARISIAN).	*Ampullina hybrida, Gisortia gigantea, Alectryonia Clot-Beyi, Cardita acuticostata, Exogyra Fraasi, Ostrea Reili?*
	CRETACEOUS.
DANIAN.	*Exogyra* cf. *Langloisi, Exogyra*, sp. nov. aff. *lateralis, Gryphæa vesicularis, Cœlosmilia laxa, Gigantichthys pharao.*
SENONIAN (SANTONIAN).	*Alectryonia acanthonota, Ostrea Thomasi, Ostrea Bourguignati (?), Gryphæa Costei, Plicatula Ferryi, Galeolaria filiformis, Holectypus* aff. *corona, Echinobrissus Waltheri, Hemiaster* cf. *Fourneli, Hemiaster Blanckenhorni, Rhabdocidaris* sp., *Pseudodiadema* aff. *Blancheti.*
TURONIAN.	*Cerithium* aff. *torosum, Nerinea Requieniana, Trochacteon gigantea, T. Salomonis, Turritella* sp., *Cardita* sp., *Biradiolites cornupastoris, B.* cf. *Mortoni,* Hippurites cornuvaccinum, Sphærulites Sauvagesi,* Cerioporа* aff. *orbiculata,* Millestroma Nicholsoni*[1] *Pseudodiadema* sp., *Phyllocœnia Toucasi,* Amorphospongia tumescens.**

(*d*) **Folds and Faults.**

A description of the region would be very incomplete without some reference to folding and faulting, especially considering that undisturbed horizontal strata are conspicuous by their absence.

Walther[2] appears to be the only observer who has attempted to describe the district with reference to its faults and folds. He recognized two principal centres of concentric dislocation, Gaa and Qulaya (Golea); the former, according to him, surrounded by four faults of small radius, and semi-circular, the latter forming a vast dome composed of beds in the form of concentric coats. In the latter dome he found a higher series above the Acteonella Beds, which he did not observe on (the western slope of) Gaa.

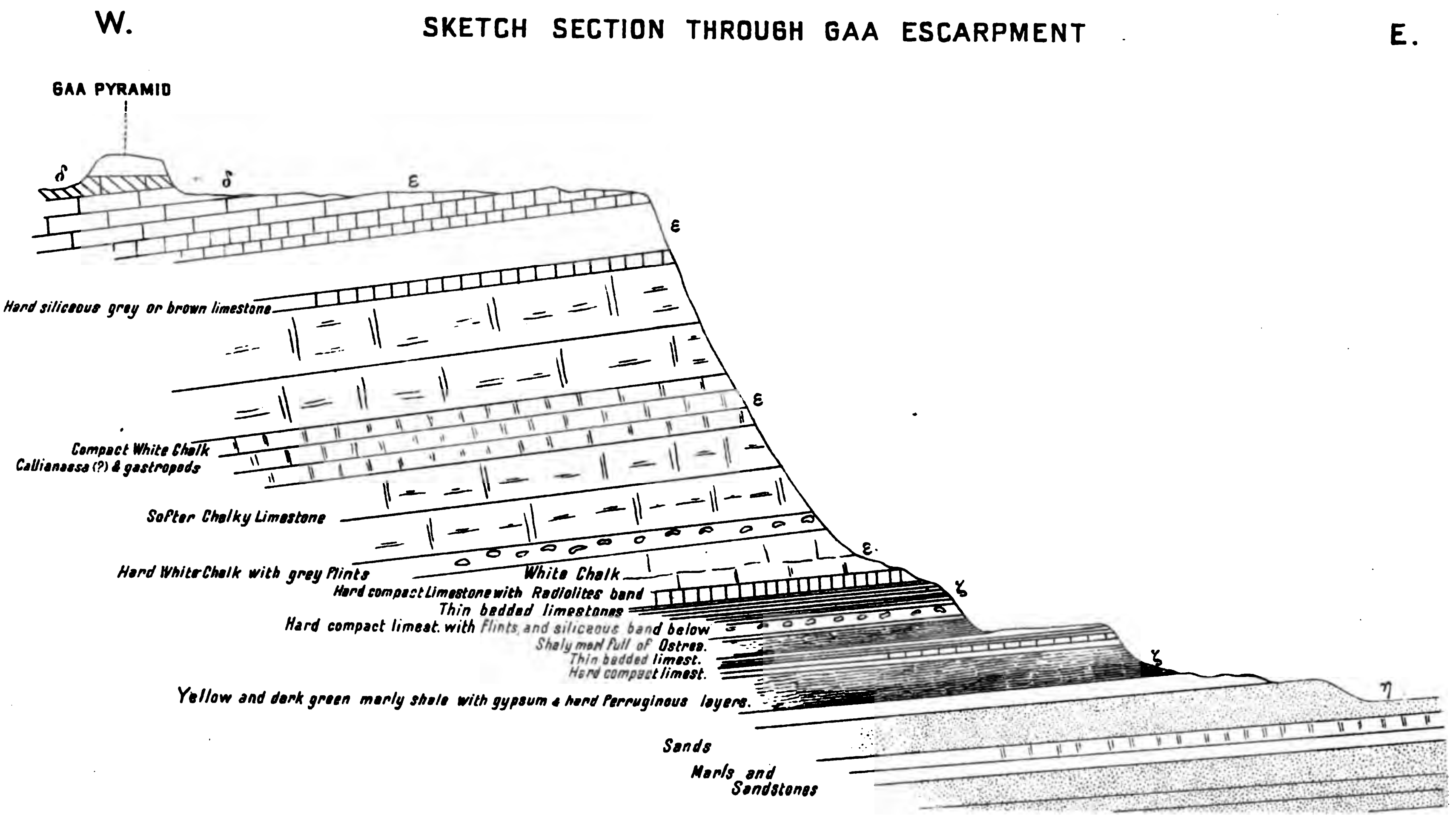
---

* These five species appear to be specially typical of the Santonian in Algeria and Tunis.

[1] Determined by Dr Gregory.

[2] *Loc. cit.* p. 5.

SKETCH SECTION THROUGH GAA ESCARPMENT


W.
E.
GAA PYRAMID
δ
δ
ε
ε
ε
ε.
ζ
ζ
η
Hard siliceous grey or brown limestone
Compact White Chalk
Callianassa (?) & gastropods
Softer Chalky Limestone
Hard White Chalk with grey Flints
White Chalk
Hard compact Limestone with Radiolites band
Thin bedded limestones
Hard compact limest. with Flints and siliceous band below
Shaly marl full of Ostrea.
Thin bedded limest.
Hard compact limest.
Yellow and dark green marly shale with gypsum & hard Ferruginous layers.
Sands
Marls and Sandstones

UPPER CRETACEOUS
- δ Acteonella - Nerinea bed.
- ε Hard Chalky limestones.
- ζ Rudistae Beds.

δ, ε: Turonian.
ζ: Cenomanian

Walther[1] also gives the positions and directions of his main bounding faults, but, as I have already shown, these are more imaginary than real.

The region is more or less naturally divisible into two areas, the first or eastern including the hills of Gaa and the dome of El Hassana, and the second or western part comprising the great hill-masses of Jebel el Ghigiga, Jebel el Haggaf and Jeran el Ful.

(1) *The Eastern District* (*Gaa*, *El Hassana*).—This is the smallest but by far the most disturbed area of the whole Cretaceous region.

The various beds have been folded into domes, which are, however, far from perfect, having been subsequently much broken by fracturing. Two domes are clearly recognizable in the district, *i.e.*, those of Gaa and El Hassana.

Gaa Dome.—A general idea of this, the larger of the two, is best obtained from the highest ground in the neighbourhood, the plateau on which are found the ancient pyramidal buildings.

The centre of the dome appears to be in the low amphitheatre of Jebel el Midauwara and here the different hard beds form ridges, running round in well-marked curves, on the north-west, west, and south-west sides, like the tiers of a theatre. On the north-east side these ridges end abruptly against a fault, while the south side is bounded by hills in which the exact disposition of the beds is not very clear, but which probably conform more or less regularly to the dome. The middle beds, the chalky limestones ε, and the upper, the Acteonella-Nerinea Limestone with its bed of shaly clay below, also conform to the same regular dome, dipping away on the west, south-west and south sides from the plateau of Gaa; on the latter side the different beds run round in horse-shoe curves, the softer often forming deep and narrow valleys between the harder.

This dome of Gaa is broken and surrounded on the north-west, north and east sides by a well-marked, long, curved fracture running from near the dome of El Hassana on the west to the south-east corner of the Jebel el Midauwara amphitheatre. At its west end, near El Hassana, short curved subsidiary faults run out from it on the north side and have the effect of several times repeating the different beds of the series δ and γ.

Further on, half a kilometre north of Gaa pyramids, it is crossed obliquely by a another fault running N.N.E. and S.S.W., which appears as a sharp broken syncline of the chalky limestones and forms a narrow valley. A little further east, just before crossing the artificial roadway leading up to the pyramids, the exact line of fault is well seen in a smooth wall of limestone 10 or 12 metres high, with here and there a certain amount of adherent fault-rock and calcite. All along this portion of the fault the successive horse-shoe ridges of the beds in the faulted portion of the dome on the north side are well seen curving round and abruptly ending off against the fault.

---

[1] *Loc. cit.* pp. 10–11.

After crossing the roadway with a well-marked curve the same fault forms the boundary between the Cenomanian sandstones and clays of Gaa amphitheatre and the highly inclined masses of these and the higher Cretaceous rocks on the east side. These latter are divided by two faults, running out in north-east directions from the main fracture, into three separate portions. The most southerly portion, near the southern end of the village of Abu Roash, consists of a great mass of rocks, including the series η, ζ, ε, δ, γ, β and part of α, some 400 metres thick, dipping at an angle of 20° to the north-west. These rocks are largely quarried, especially on either side of the small valley which cuts through them, leading from the Kirdassa Cemetery to the large amphitheatre. The soft beds at the top of the series, β and part of α, are found forming a small valley in which the White Chalk ends off abruptly against the fault-scarp of the middle group of rocks, formed of the series ε, δ, γ and β dipping in the same direction, north-west, but at a much steeper angle of 50–60°.

In this steeply inclined mass, 200 metres thick, the upper flinty beds γ meet the White Chalk of a syncline to the north along a line of fracture, which sometimes resolves itself into a very sharp, scarcely broken, fold in which the whole succession of beds γ to β appears to be present.

This syncline of the White Chalk and associated beds is well seen just south-west of the barracks to the north of Abu Roash village. The northern part of the fold passes into the faulted dome near the bottom of the Gaa roadway. In this dome the outcrops of the different beds of the Plicatula and Ostrea Series and the White Chalk form a number of U-shaped curves, the dips always away from the centre, which just to the north of the roadway is formed of a saddle of the Acteonella-Nerinea Beds.

The very peculiar weathering of the White Chalk in this neighbourhood has been mentioned by Schweinfurth[1] and is caused by the differential action of blown sand on the tilted layers of the chalk which, varying as it does in hardness from point to point, is left as a sea of crested water separated by hollows.

---

[1] *Loc. cit.* p. 1.

For further information on the faults and folds of Gaa reference should be made to the accompanying maps and sections, which will give a much better idea than any description.

Dome of El Hassana.—Occupying the comparatively low ground between Gaa and the eastern slopes of Ghigiga, this dome is at once conspicuous and striking owing to its clearly cut valleys and ridges and the beautiful regularity of their curves. With the absence of all vegetation and surface accumulations, it stands out like a gigantic geological model (Plate VI).

The dome is bounded and cut through on the east side by a little wadi or valley, the Derb el Hassana, coinciding with a fault, and forming a pass through the hill-range. Between the Derb el Hassana and the base of the western slope of Gaa, there is, however, a portion of the Gaa dome, made up of beds of the flinty series γ.

The dome of El Hassana comprises the series ε, δ, γ, and β. The central mass is made up of hard, and softer, compact chalky limestones with occasional cherty bands, *i.e.* the same series ε that forms the Gaa escarpment. These chalky limestones form the hard central core, the beds being bent into a sharp dome with dips on the outside of 40° and 50°. This core is surrounded by a narrow valley or gully which is cut out in the soft shales and clays below the Acteonella-Nerinea Limestone, which forms the next cencentric ridge, the beds dipping at angles as high as 60°. On the south side this limestone ridge is regularly followed by another concentric valley, cut out in the soft sandy and marly beds at the base of the flinty series γ. The hard flinty limestones immediately follow on forming a second regular curved ridge, the beds of which dip at an angle 35°. To the south of this ridge, on the low ground, the different beds of the Plicatula and Ostrea Series (β) are found, their outcrops forming slight ridges and hollows concentrically placed with regard to the centre of the dome.

The ridge and valley formed by the beds of the flinty series (as also those of the still higher series β), are not continuous round the dome. Followed westwards from the Derb el Hassana they are found to run abruptly (see photograph, Plate VI) into the lower part of another ridge which, when examined, proves to consist of the *Acteonella-Nerinea* limestone and the clays below. At first sight it is almost impossible to believe that these are the same beds as those forming the first valley and ridge outside the core of the dome: but such is the case, and the cause is due to the fault shown on the map. This fault dies out northwards and the limestone and clay beds on either side are nearly continuous on the extreme W.N.W. of the centre of the dome.

The beds of the Flinty Series are also found at the base of the dome on its north side, forming small ridges on the plain, slightly displaced laterally owing to the fault just mentioned.

Although the folding in the domes of El Hassana and Gaa is much sharper that that found in Jebel el Ghigiga, Jebel el Haggaf and Jeran el Ful, the limestones have seldom been rendered even slightly crystalline. This is somewhat surprising when the highly crystalline character of the beds in the western division is remembered. That during this folding the beds underwent intense pressure is shown from the manner in which the flints of the Flinty Series have been brecciated. The folding must therefore have taken place subsequently to the formation of these flints, at which time the beds were probably fairly well consolidated.

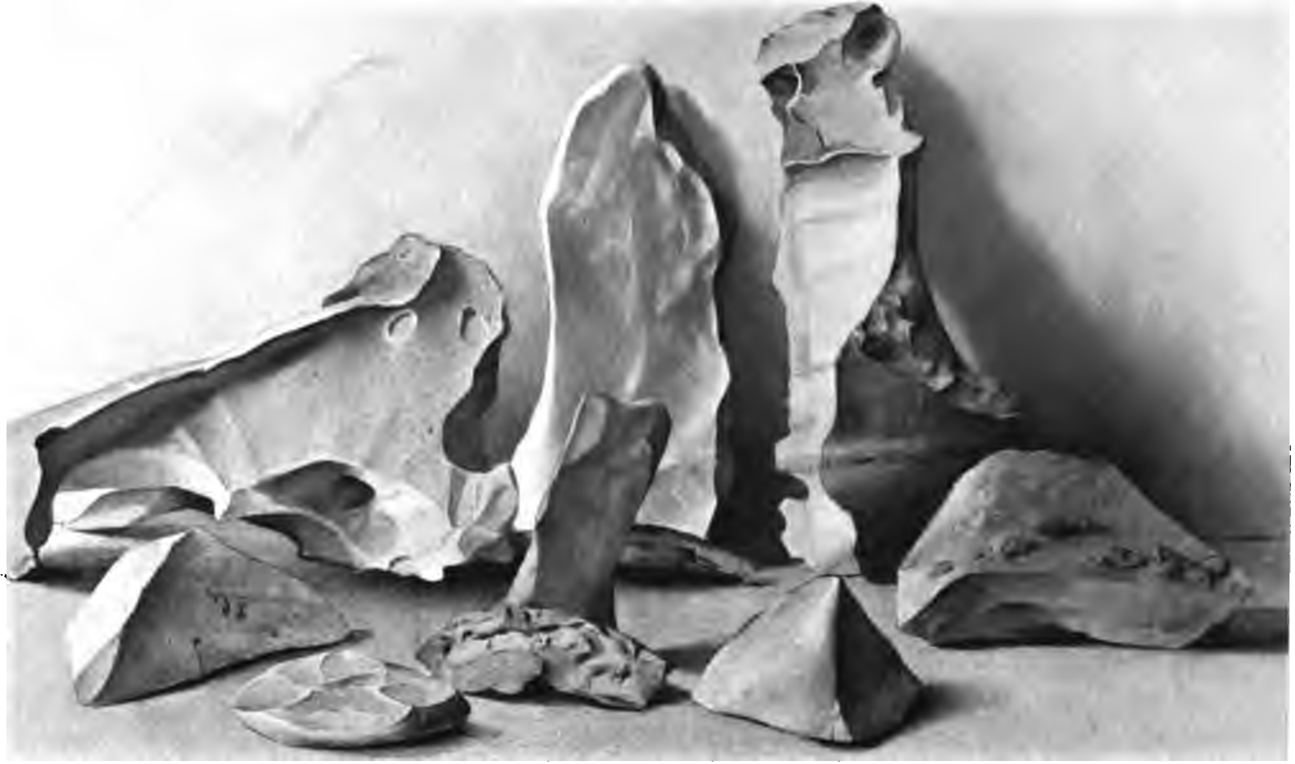
(2) *The Western District (Jebel el Ghigiga, Jebel el Haggaf, Jeran el Ful).*—The main feature of this district is at once seen to be a double anticlinal fold, separated by a synclinal trough or basin, (Section V). The axes of these folds lie E.N.E. and W.S.W. The northern saddle forms the great hill-mass of Jebel el Ghigiga, which is separated from the southern by the basin forming the easterly continuation of the depression of Sidr el Khamis. The southerly anticline is imperfect in that the centre of the mass has been denuded, but the northern side is seen in the hill-mass of Jebel el Haggaf, whose beds dip at 21° N., while the southern half is represented by the range of Jeran el Ful, the crystalline limestones of which dip steadily southwards at almost the same angle. The intermediate area[1] is occupied by low ground with loose gravel-covered hills, but a kilometre or two further west the beds on either side of the fold are continuous across.

In these folds the beds of the series ε, δ and γ are those which have been chiefly metamorphosed; in most places these beds are very hard and highly crystalline, being in fact often similar to the best marbles. Fossils have in consequence been more or less obliterated. The beds of the series β and α have seldom or never become crystalline, and owing to their softness have since been denuded, and now are only found on the low ground, such as the valley on the west side of Jeran el Ful and in the depressions of Sidr el Khamis and Wadi el Qurn. The crystalline rocks on the other hand form hard prominent masses. Round the extremity of the plateau of Ghigiga, at the top of the flanks

---

[1] Walther considers faults bound the escarpments of Jebel el Haggaf and Jeran el Ful. That the beds over the intermediate area have been let down by a trough fault is not admissible for several reasons, the manner in which the beds are seen to be continuous a little further west, suggesting that this area has been carved out by denudation and not faulted down. The beds in the centre of the fold may not have been rendered so highly crystalline as those on the flanks, and thus have been subsequently more easily denuded.

PLATE XI



Photogravure by Dr E Albert & Co Munich

FRAGMENTS OF CHERTY AND CRYSTALLINE LIMESTONE SHAPED BY WIND BORNE SAND [illegible] depression of Sidi el Kharis, [illegible] [illegible] bed [illegible] of [illegible] series [illegible] a number of perfectly concentric valleys [illegible] [illegible] to the differences of weathering. Such [illegible] [illegible] and [illegible] are in fact characteristic of the whole of Abu Roash. [illegible] [illegible] [illegible] rocks [illegible] [illegible] [illegible] perpendicular folds. On the north [illegible] the [illegible] mass of Jebel el G[illegible] is bounded by a [illegible] fault which runs continuously along the foot of the high ground. [illegible] this fault the concentric ridges and troughs of the cliff [illegible] [illegible] end, and on the other side of the fault, [illegible] [illegible] White Chalk. This fracture is traceable for 5 kilometres [illegible] the [illegible]-west corner of the Cretaceous [illegible] point [illegible] S. [illegible] [illegible] hill of El Qurqur. There it appears to gradually die out [illegible] [illegible] forming a junction line between the series [illegible] [illegible] of

Another large fault, apparently starting from El Qalaya, runs east [illegible] for a kilometre along the base of the hill-slopes, and finally turns [illegible]wards, running in [illegible] north side of the dome of El Hassana separating the latter from the [illegible] [illegible] the beds on either [illegible] at the point of junction [illegible] and [illegible].

[illegible] glance at Section [illegible], which is drawn to scale [illegible] the [illegible] hill-range from the Nile Valley on the east to the [illegible] [illegible] junction on the west, shows the different strike faults and [illegible] effect on the various beds. The downthrow varies from a few [illegible] up to 250 and along this line is always to the east. Taking the [illegible] the central parts of the range where they are almost horizontal, [illegible] it is noticeable that although at every fault the beds are let [illegible] with a downthrow to the east, before the next fault is reached [illegible] [illegible] has taken them up to the original level. The bed [illegible], as a rule, been [illegible] bodily to lower levels [illegible] [illegible] [illegible] by faults [illegible] [illegible], while [illegible] [illegible] [illegible] [illegible] [illegible] have [illegible] nearly stationary.

[illegible] has now been said about this little subject of faults and [illegible] [illegible] [illegible] to work [illegible] in the field, are [illegible] difficult to explain [illegible].

[illegible] the Folds and Faults. Walther says: "Il me reste donc [illegible] [illegible] que les failles en question soient ou contemporaines [illegible]

[illegible] 12

[illegible]

facing the depression of Sidr el Khamis, the alternating hard and soft beds of the series γ and δ form a number of perfectly concentric valleys and ridges, owing to the differences of weathering. Such concentric ridges and gullies are in fact characteristic of the whole of Abu Roash, and are found wherever the rocks have been bent into these peculiar folds.

On the north side the hill-mass of Jebel el Ghigiga is bounded by a large fault which runs continuously along the foot of the high ground. Against this fault the concentric ridges and troughs of the different beds abruptly end, and on the other side of the fault, in contact with them, is the White Chalk. This fracture is traceable for 5 kilometres, from the north-west corner of the Cretaceous to a point one kilometre S.S.E. of the hill of El Qulaya. There it appears to gradually die out after successively forming a junction line between the series ε and those of α, β, γ.

Another large fault, apparently starting from El Qulaya, runs eastwards for a kilometre along the base of the hill-slopes, and finally turns southwards, running in on the north side of the dome of El Hassana and separating the latter from the Ghigiga massif, the beds on either side at the point of junction being γ and ε.

A glance at Section IV, which is drawn (to scale) through the entire hill-range from the Nile Valley on the east to the Eocene-Cretaceous junction on the west, shows the different strike faults and their effect on the various beds. The downthrow varies from a few metres up to 250 and along this line is always to the east. Taking the beds of the central mass of Ghigiga, where they are almost horizontal, as a datum, it is noticeable that although at each fault the beds are let down with a downthrow to the east, before the next fault is reached their inclination has taken them up to the original level. The beds in fact have not, as a rule, been faulted down bodily to lower levels, but in each section bounded by faults, the enclosed beds, while let down to a considerable extent along one fault-plane, at the other have remained nearly stationary.

Enough has now been said about this difficult subject of faults and folds, which often troublesome to work out in the field, are infinitely more difficult to explain on paper.

Age of the Folds and Faults.—Walther[1] says "Il ne reste donc qu'à admettre que les failles en question soient ou contemporaines à la formation de la vallée du Nil[2], ou postérieures et alors nées à une époque géologique relativement récente." This conclusion appears to have been derived from the idea that the faults, etc., of the Abu Roash region had a connection with the various faults and folds which are often traceable in the wadis of the Eocene formation on the opposite side of the Nile Valley; and because these wadis are not continued into the Western Desert.

---

[1] *Loc. cit.* p. 12.

[2] That the Nile Valley is of comparatively recent age, probably dating not further back than early Pliocene times, seems probable. See the writer's *Découvertes géologiques récentes*, etc., and *Notes sur la géologie du désert oriental de l'Egypte*, VIII^{e} Congrès géolog. intern., 1900. Paris, 1901, by Messrs. T. Barron and W. F. Hume.

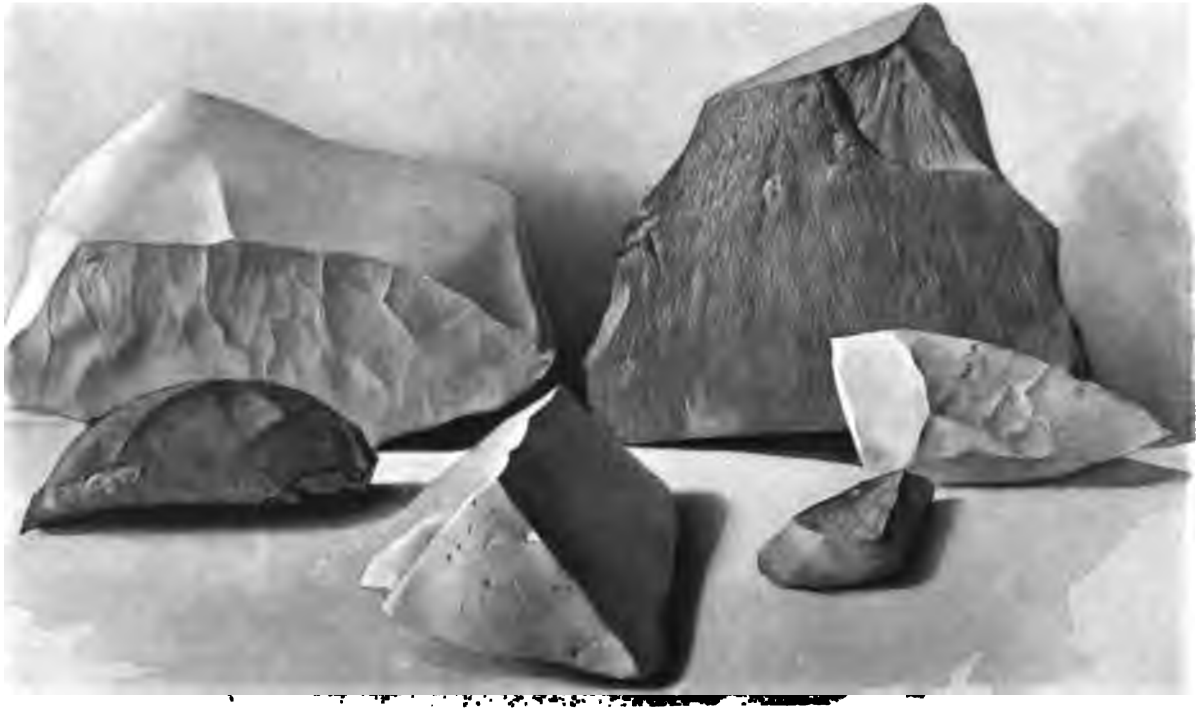
From what has already been said about the horizontality of the surrounding Eocene rocks and the unconformable manner in which they are laid on to the often highly inclined Cretaceous beds, there is not the slightest doubt that the folding and faulting of the Cretaceous took place, not at a comparetively recent Tertiary date, but in pre-Eocene times. After the deposition of the uppermost beds of White Chalk elevation must have gradually taken place, and it was probably during this time that the beds underwent lateral compression from the north and south sides, resulting in the well-marked folds, extensively fractured by the faults of which we see the remains at the present time. After elevation had exposed the beds as a land-mass, denudation probably proceeded apace, and doubtless effected a considerable amount of sculpture and erosion before subsidence carried the area gradually below sea-level. This subsidence probably continued throughout Eocene times and it was only towards the end of the latter epoch that the upper part of the subsiding Cretaceous land was submerged and received successively overlapping deposits. It is even doubtful if the uppermost heights of the Cretaceous were ever entirely submerged, certain it is that they now show no trace of Tertiary deposits.

Since Pliocene times, when the sea effected a considerable amount of erosion on the lower grouud, as evidenced by the old bored sea cliff below the Pyramids of Giza, denudation has no doubt rapidly continued, with the result that to-day, being absolutely bare and devoid of vegetation, the region stands out beautifully sculptured, resembling more than anything else a gigantic geological model.

(*e*) **Weathering.**

The general results of weathering in this region are worthy of a separate study, but it is only proposed at present to offer a few general remarks on the subject.

The effects of the action of wind-borne sand in the denudation of rocks are perhaps more beautifully displayed at Abu Roash than in most other localities in the Western Desert. This is no doubt due



Photogravure by Dr E. Albert & Co Munich

DREIKANTER AND VERMICULAR SURFACE PRODUCED IN CRYSTALLINE LIMESTONE BY WIND-BORNE SAND

[illegible] great pressure to the [illegible]
[illegible] state and crystalline [illegible]
[illegible] which is present, are [illegible]
[illegible] scattered [illegible]
[illegible] white [illegible] are [illegible]
[illegible] enough to allow of the [illegible]
[illegible] The [illegible]
[illegible] the [illegible] assume
[illegible] exposed to the [illegible]
[illegible] Plate XI [illegible]
[illegible] lines [illegible] their [illegible] that
[illegible] substances [illegible] different [illegible]
[illegible] are as [illegible]
[illegible] with [illegible]
[illegible] latter are more [illegible]
[illegible] or [illegible]
[illegible] flat-shaped fragment [illegible]
[illegible] its exposed [illegible]
Plate XII exhibits [illegible]
[illegible] two blocks of this [illegible]
[illegible] are specimens [illegible]
[illegible] remarkable [illegible]
[illegible] sand. [illegible]
[illegible] but it is very [illegible]
[illegible] is a hard grey [illegible]
[illegible] altered [illegible]
[illegible]
[illegible] similar rocks [illegible]
[illegible] kinds [illegible]
[illegible]
[illegible]
[illegible] taken [illegible] in [illegible]

in great measure to the abundance of suitable material—hard semi-crystalline and crystalline limestones—types of rock which, according to the writer's experience, are more than most others visibly attacked and beautifully sculptured by the agent in question. Softer rocks—notably ordinary white chalk—are worn away at a greater rate, but are not hard and durable enough to allow of the exquisite sculpturing produced on a harder medium. The three accompanying illustrations will serve to show some of the peculiar shapes assumed by rock-fragments when lying on the desert surface exposed to the natural sand-blast.

In Plate XI, the larger specimens are fragments of cherty and crystalline limestones and owe their peculiar shapes to being composed of two substances of different degrees of hardness. The softer more calcareous part of the rock is eaten out with considerable rapidity compared with the harder more siliceous portion. The more irregular the latter the more curious the resulting stone. Two well formed "dreikanter" or pyramid pebbles are also shown on this plate, while a third flat-shaped fragment of limestone shows the numerous facets into which its exposed surface has been worn.

Plate XII exhibits several more pyramid pebbles of different shapes. The two blocks in this plate occupying the top-right and bottom-left positions are specimens collected near Heluan to show the beautiful and remarkable "vermicular" surface produced on this type of rock by drifting sand. The term "vermicular" is used for want of a better word, but it is very applicable to the type of surface in question. The rock is a hard grey crystalline, and probably siliceous, limestone, a locally altered bed in the Eocene series of the Eastern Desert south of Cairo. "Vermicular" surface may, however, be frequently observed on similar rocks in different parts of the Nile Valley, but it is only on certain kinds of limestone that the structure is produced. It would appear to depend on the internal structure of the rock rather than on any external conditions, but may perhaps be partly due to the irregular paths taken by sand-grains in motion.

IV.—LIST AND EXPLANATION OF ILLUSTRATIONS.

Plates I–II.—Maps.

Plate I.—Sketch-map to show position of Cretaceous massif of Abu Roash with reference to Cairo and the Nile Valley.

Plate II.—Geological map of the Cretaceous Region of Abu Roash near the Pyramids of Giza; Scale $\frac{1}{2000}$.

Plates III–X.—Photographs.

Plate III.—*Jebel el Midauwara.*—The low ground in the centre is the bottom of the amphitheatre of Gaa and is cut out in the lowest beds, the Cenomanian sandstones and clays, (η). Surrounding these and forming concentric tiers are the Rudistæ Beds (seen in the background, with white limestone bands, passing round to the base of the high escarpment). The high cliff is part of the Gaa escarpment and is formed, above the Rudistæ Beds at the base, of the chalky limestones (ε).

In the foreground the highly inclined ridges include part of ε, δ, and part of γ. These beds are dipping at about 55° N.W. and are separated from the above-mentioned Cenomanian beds, occupying the central low ground, by a fault.

The faint ridge on the horizon marks the eastern slopes of Jebel el Ghigiga.

The view is taken from a point 1 kilometre W.S.W. of Abu Roash village, and faces S.W.

Plate IV.—*North-east end of Jeran el Ful hills.*—Showing the characteristic conical peaks of this Cretaceous range. The rock is a hard highly-crystalline limestone (ε) and the beds are dipping at about 20° S.

The view is taken from the valley at the N.E. end of the range; sun setting behind heavy clouds.

Plate V.—*Jebel el Haggaf.*—Showing the southern escarpment of Jebel el Haggaf, *i.e.* that facing Jeran el Ful.

The lowest beds at the base of the cliff are the Cenomanian sandstones and clays (η), the main part of the cliff above being formed of the Rudistæ beds (ζ). The upper part of the cliff and the plateau are formed by the highly crystalline limestones of series ε, the dark-weathering bed being No. 17 of Section VII. The dip of the beds is about 20° N.N.W. The foreground shows the grooving by wind-borne sand on these crystalline limestones.

The view is taken from the west side of the small gully cutting through Jebel el Haggaf to Sidr el Khamis, 8 kilometres W.N.W. of the Pyramids of Giza; faces N.E.

Plate VI.—*Part of the Dome of El Hassana.*—Shows the southern portion of this dome. The valley with the tents, in the foreground, is the Derb el Hassana. On the right is seen part of the central core of the dome, formed of the chalky limestones ε. The surrounding valley is cut out in the soft clays below the Acteonella-Nerinea Limestone which forms the next ridge, the near extremity of which forms the centre of the photograph. The next valley on the left is cut out in the soft marly limestones at the base of the flinty limestone series, the hard upper beds of which, containing the bands of flint, form the ridge on the left-hand side of the picture. All the beds of the dome are seen dipping at high angles. The whitish flinty limestone series, on the left, if followed backwards is seen in the centre-background to run abruptly into a dark ridge running in a much wider curve across the back of the picture. This ridge is made up of the Acteonella-Nerinea Limestone with the clays below, and is identical with the central ridge of the dome above-mentioned. As already noticed in the geological description, the peculiar repetition of this bed is due to a fault, the position of which is best seen on the map, Plate II.

The high ridge on the horizon to the left is the eastern flank of Jebel el Ghigiga.

The Derb el Hassana in the foreground is a line of fault which cuts off the ridges of the dome from the lower part of the Gaa dome. The view is taken from one of the ridges near the bottom of the western flanks of Gaa, and faces west.

Plate VII.—*Unconformable Junction of Eocene and Cretaceous, (with intervening pebble-bed). Cliff on west of Sidr el Khamis.*—The lower white bed on the right side is the Cretaceous White Chalk (α). The irregularity of its upper surface is well seen, and above it the overlying pebble bed about a metre thick, made up of hard crystalline semi-rounded Cretaceous fragments, often cemented by limestone debris and sand into a hard conglomerate. Above is seen a thick (2 metres) limestone band, gritty at the base, but becoming purer and shelly above. This forms the base of the Eocene and belongs to the Upper Mokattam formation. The exact locality is the cliff bounding the depression of Sidr el Khamis on the west side, 11½ kilometres W.N.W. of the Pyramids of Giza.

Plate VIII.—*Junction of Eocene and Cretaceous in south-west corner of Sidr el Khamis.*—The lower, Cretaceous, beds (α, β) are seen dipping westwards at about 10°. The top of the horizontal ridge is formed of Upper Mokattam (Middle Eocene) limestones, dipping away from the observer, *i.e.* southwards, at 2-3°.

This view is taken from a point in Sidr el Khamis 10½ kilometres nearly due W. of the Pyramids of Giza. Faces south.

Plate IX.—*Crystalline Limestones of Jeran el Ful (showing erosion by wind-borne sand).*—The peculiar conical peaks and separating pavement-like areas of smoothed grooved rock are seen. All the beds are very hard and crystalline and belong to series δ and ε. Dip is about 20° S.

Taken from one of the most easterly peaks, facing west.

Plate X.—*Bank of Biradiolites cornu-pastoris* d'Orb. *Turonian of Dome of El Hassana.*—One of the great reef-like masses of this lamellibranch which occur here and there in the Acteonella-Nerinea Bed is here shown.

SECTIONS I–VIII.

SECTION I.—Diagrammatic section through escarpment (same as Sect. II), 4 kilometres W. of the Pyramids of Giza.

SECTION II.—Diagrammatic section through escarpment 3 kilometres W. of Pyramids of Giza.

SECTION III.—Diagrammatic section across the Cretaceous-Eocene junction of Sidr el Khamis, 12 kilometres W.N.W. of the pyramids.

SECTION IV.—Section from near Abu Roash in the Nile Valley through Cretaceous massif to junction with Eocene west of Sidr el Khamis.

SECTION V.—Section from Jeran el Ful to Jebel el Ghigiga.

SECTION VI.—Detailed Section across Jeran el Ful hills.

SECTION VII.—Section across Jebel el Haggaf.

SECTION VIII.—Sketch-section through Gaa Escarpment.

PLATES XI–XIII.—PHOTOGRAVURES (from drawings).

PLATE XI.—Fragments of cherty and crystalline limestone shaped by wind-borne sand.

PLATE XII.—Dreikanter and vermicular surface produced in crystalline limestone by wind-borne sand.

PLATE XIII.—Curiously-shaped fragment of cherty crystalline limestone.

[illegible] No. III.

[illegible] 3 [illegible] W. of

[illegible] across [illegible] section of [illegible]

[illegible] No. VIII. through [illegible]

[illegible]

[illegible] Uplifts

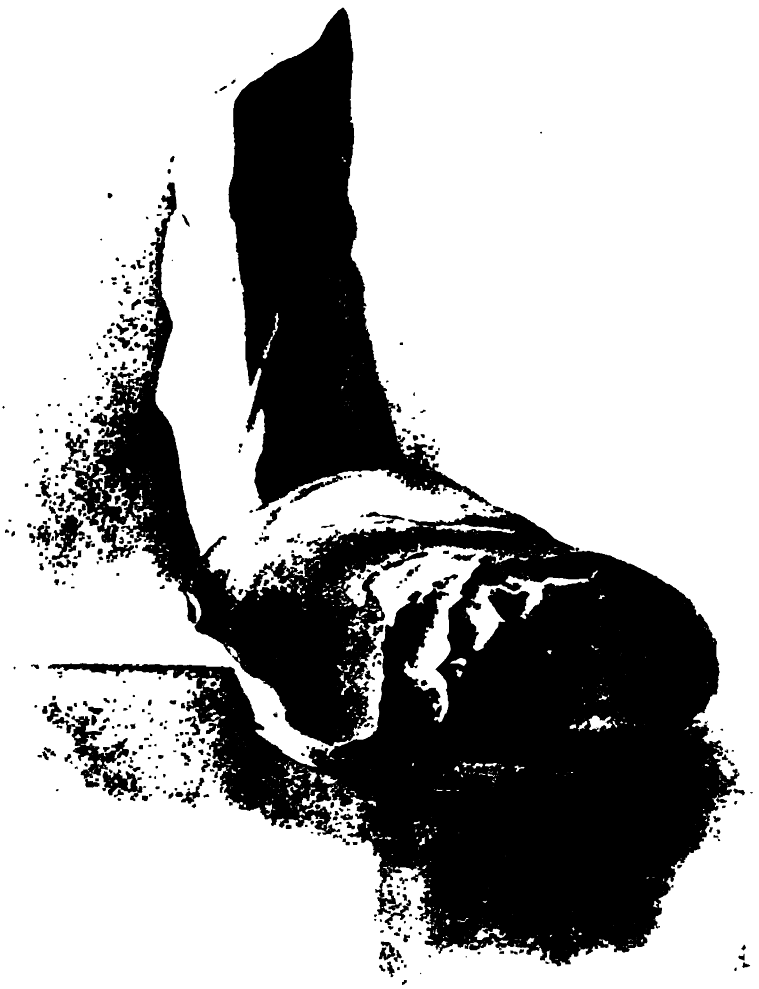
[illegible] escarpment.

[illegible] (from drawings).

[illegible] stone shaped by wind

[illegible] produced on crystalline

[illegible] crystalline limestone



Photogravure by Dr E. Albert & Co Munich

CURIOUSLY-SHAPED FRAGMENT OF CHERTY CRYSTALLINE LIMESTONE

Gaylord
SPEEDY BINDER
Syracuse, N. Y.
Stockton, Calif.

UNIVERSITY OF MICHIGAN
3 9015 01937 0009

DO NOT REMOVE
OR
MUTILATE CARD